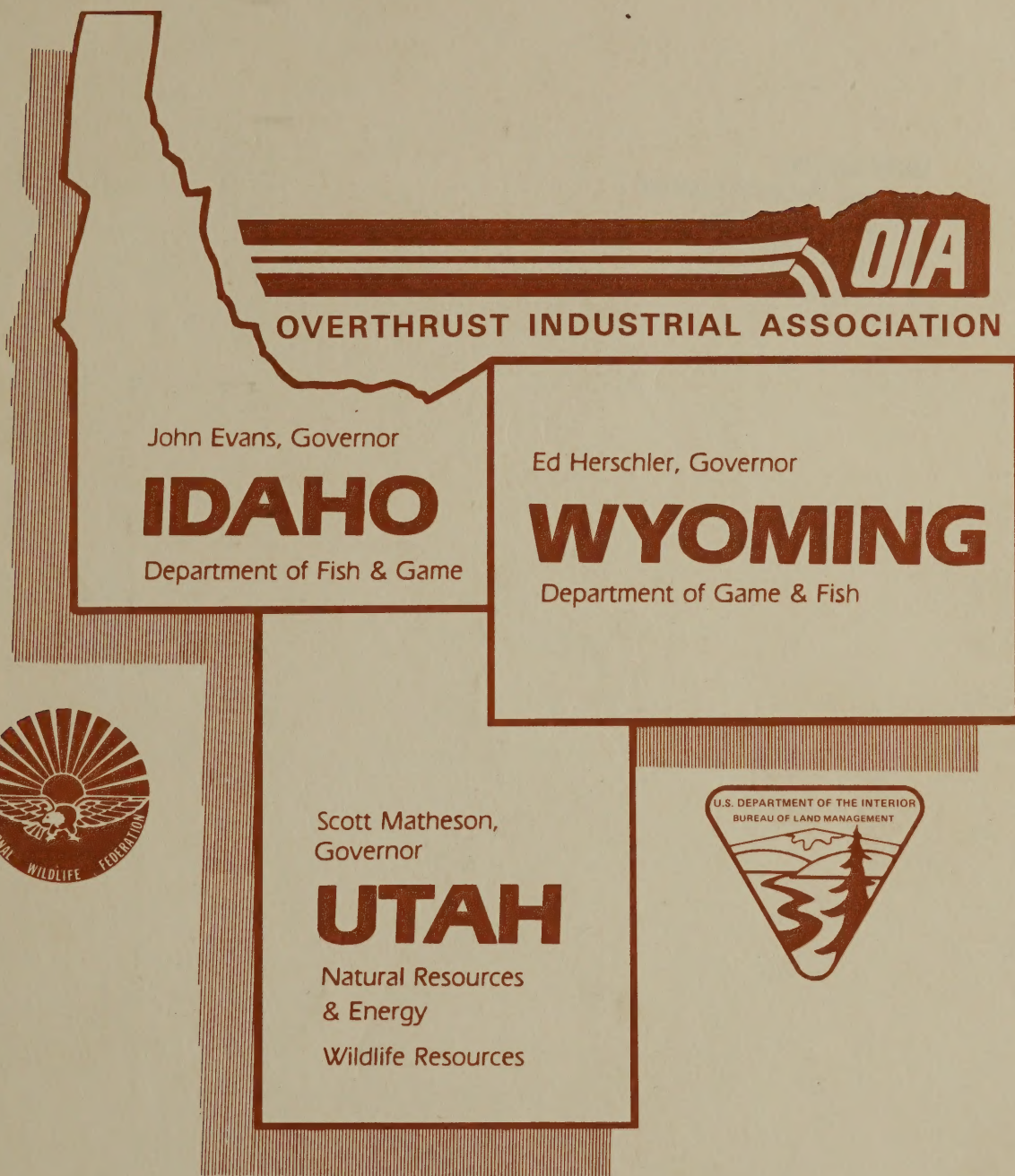




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COOPERATIVE WILDLIFE PROGRAM

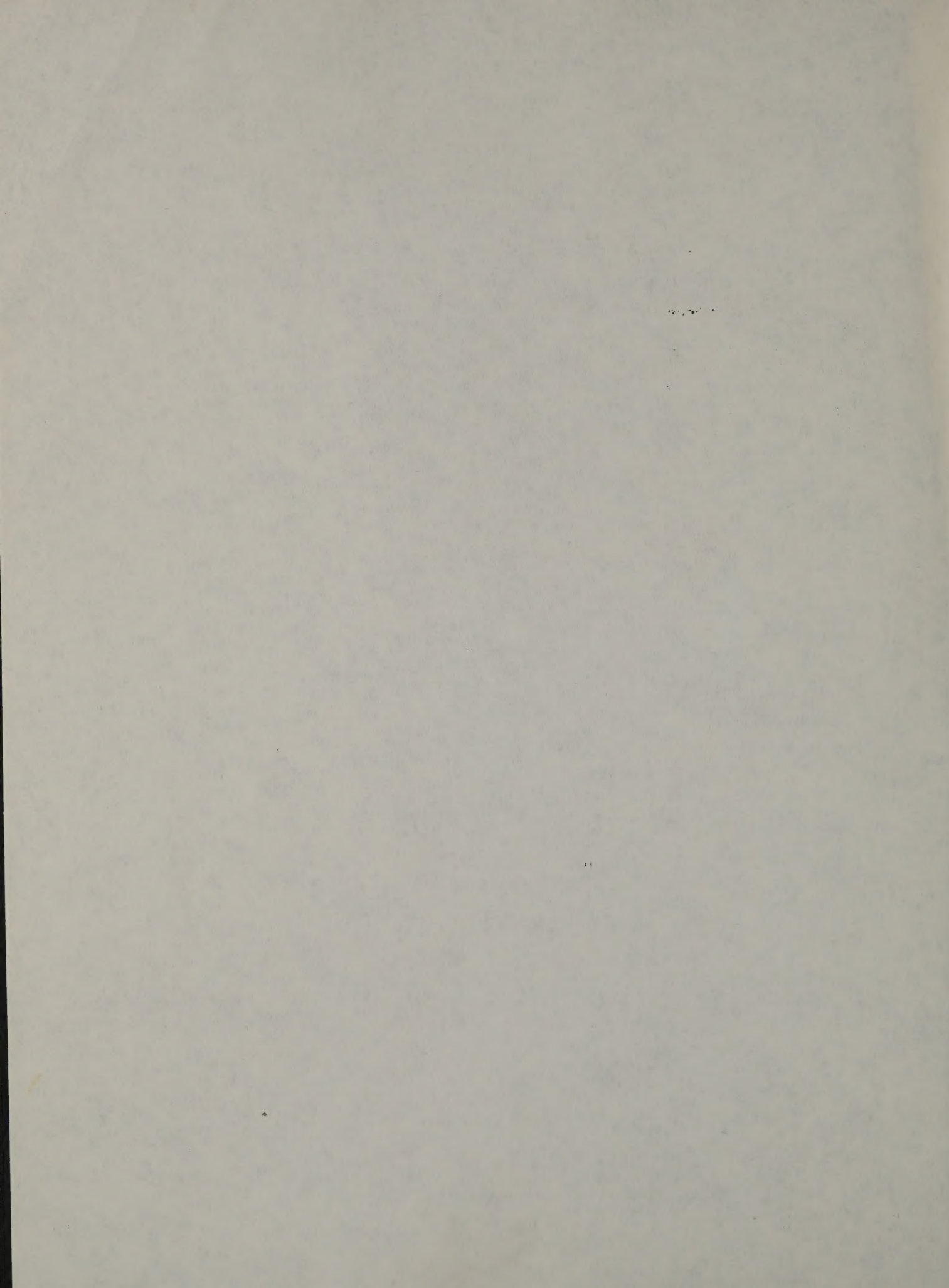


MARCH, 1984

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PROJECT REPORT

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ABSTRACT

Published and unpublished information pertinent to the impacts of petroleum industry development on wildlife has been reviewed for application to the Overthrust Belt in Wyoming, Idaho and Utah. Categories of inquiry included analytical/predictive procedures, effects of oil and gas development on wildlife, availability of specific wildlife information for the study area, and mitigation practices. Findings are reported for each task-category and recommendations for research are presented. An annotated bibliography has been prepared as a separate document.

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Phase I included six tasks the purpose of which were to:

1. assess analytical/predictive procedures for identifying environmentally sensitive areas and evaluating impacts. These included methods for defining issues, managing data, evaluating wildlife habitat, and predicting impacts.
2. comprehensively review the published North American literature regarding effects of resource development on wildlife resources.
3. identify and review unpublished literature and related data available from agencies, private individuals, industrial operators, and universities concerning wildlife resources within the study area.
4. conduct a public workshop within the project study area to solicit public concerns and conduct two review meetings to present the findings of this study to representatives of the BLM and to solicit their comments.
5. review the literature on mitigation practices currently applied in oil and gas development both within and outside of the study area. Regulatory requirements, wildlife management techniques, and reclamation techniques were reviewed.
6. synthesize all results into a set of recommendations for further study in Phase II of the Wildlife Management Study. These are presented as objective and specific projects.

This report presents the findings of each task. It is accompanied by companion appendices that include abstracts for reports reviewed in Task 1, annotated bibliographies for Tasks 2 and 3, summaries of public workshops, and other incidental materials.

INTRODUCTION

OBJECTIVES AND PRODUCTS

The objective of Phase I of the Overthrust Industrial Association's Cooperative Wildlife Program Wildlife Management Study was to assess the state of current knowledge concerning wildlife resources in the Overthrust Belt in Wyoming, Idaho and Utah. The overall Study will consist of this literature review, collection and analyses of necessary field data, formulation of analytical procedures to identify environmentally sensitive areas, and compilation of a list of potential mitigation measures. Phase I was designed to focus the overall study by determining the sufficiency of existing information and analytical methods for understanding, predicting and mitigating the effects of development on wildlife resources.

Phase I included six tasks the purpose of which were to:

1. assess analytical/predictive procedures for identifying environmentally sensitive areas and evaluating impacts. These included methods for defining issues, managing data, evaluating wildlife habitat, and predicting impacts.
2. comprehensively review the published North American literature regarding effects of resource development on wildlife resources.
3. identify and review unpublished literature and related data available from agencies, private individuals, industrial operators, and universities concerning wildlife resources within the study area.
4. conduct a public workshop within the project study area to solicit public concerns and conduct two review meetings to present the finding of this study to representatives of the PCC and to solicit their comments.
5. review the literature on mitigation practices currently applied to oil and gas development both within and outside of the study area. Regulatory requirements, wildlife management techniques, and reclamation techniques were reviewed.
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PROJECT TEAM

The team responsible for conducting the Phase I literature search and review is shown in Figure 1-1. This project was undertaken by Larry Seeman Associates, Inc. (LSA) and the University of Wyoming (UW). LSA had primary responsibility for technical elements as follows: Task 1 - Analytical/Predictive Procedures; Task 3 - Local Knowledge (Utah); and Task 4 - Public Workshops and PCC Review. UW had primary responsibility for Task 1 - Habitat and Environmental Assessment, Task 2 - Effects of Development on Wildlife Resources, Task 3 - Local Knowledge (Wyoming), and Task 5 - Mitigation and Reclamation Practices. Idaho Department of Fish and Game performed the local knowledge search in Idaho. LSA and UW shared responsibility for Task 6 - Phase II Work Program and had reciprocal review responsibility on all tasks.

Dr. Larry Stromberg was Co-Project Leader for LSA. Dr. Stanley Anderson was Co-Project Leader for UW. Dr. Stromberg was responsible for contract administration, LSA's participation in the public workshops and PCC review meetings, coordinated and supervised LSA's technical staff, prepared progress reports submitted to the PCC, and was responsible for the format and content of all project reports. Dr. Anderson was responsible for contract administration, UW's participation in the public workshop and PCC review meetings, certain technical aspects of the work program, and supervision of technical staff.

Other participants in this study are listed below in alphabetical order:

George Baxter (UW) - Fish
 Richard Berg (UW) - Computer specialist, analytical methods
 Harold Bergman (UW) - Water quality
 Edward DePuit (UW) - Reclamation
 Kenneth Diem (UW) - Game birds
 David Duvall (UW) - Amphibians and reptiles
 William Gern (UW) - Amphibians and reptiles
 Henry Harlow (UW) - Mammals, physiological stress
 Wayne Hubert (UW) - Fish, threatened and endangered species
 John McGrath (LSA) - Mitigation analyses
 Joseph Meyer (UW) - Bibliographic search, riparian systems
 Michael Parker (UW) - Bibliographic search
 Larry Seeman (LSA) - Report review, public involvement, Phase II work program
 Thomas Wesche (UW) - Analytical Methods, Riparian Systems

Connie Calica, John Dupree, Helen Chang, and Kathleen Leslie, all of LSA, were responsible for word processing and report production. For UW John Cook, Liza Cuthbert-Millett, and John Ward assisted in the literature search and review and Jonnie Hoggan and Angela Brummond entered bibliographic data and typed reports.

FIGURE 1-1

PROJECT TEAM AND RESPONSIBILITIES

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Task 5 - Mitigation Analysis

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Task 6 - Phase II Work Program

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SUMMARY AND CONCLUSIONS

INTRODUCTION

The Overthrust Industrial Association (OIA) is currently carrying out its Cooperative Wildlife Program, which consists of three elements. These are law enforcement assistance, an environmental awareness training program, and a wildlife management study. This report summarizes the technical information developed in Phase I and outlines a program of proposed research for Phase II based on Phase I.

The goals and work programs carried out in the Cooperative Wildlife Study were defined and prescribed by the Project Coordinating Committee (PCC), a management group comprising representatives of wildlife and land management agencies, private wildlife interests, and industry. A five-county area centered on the Bear River Divide, including Uinta and Lincoln Counties in southwestern Wyoming, Rich and Summit Counties in northeastern Utah, and Bear Lake County in southeastern Idaho, is the focal point for the study. This is the current operating area for the OIA.

This report concludes Phase I of the study. In this phase, the authors comprehensively evaluated existing information on wildlife and wildlife-related resources in the study area, critically reviewed literature on the impacts of land use and development on wildlife, assessed mitigation practices related to oil and gas and related development, and evaluated the methods presently used to analyze habitat and predict development impacts.

Phase II will consist of studies designed to complete the base of information available on resources, methods, impacts, and mitigation practices. It Phase III will combine the results of Phases I and II into a management-oriented product that: 1) can support predictions of the impact of oil and gas and related development; 2) identifies potentially sensitive areas within the five-county area; and 3) provides a list of workable, cost-effective mitigation measures that can be incorporated into plans for future development in both the study area and adjacent areas into which oil and gas development may expand in the future.

PHASE I OF THE STUDY

Phase I was divided into six tasks. This report is the product of Task 6. The first five tasks and their specific purposes were:

Task 1. Assess analytical and predictive procedures for identifying environmentally sensitive areas and evaluating impacts. These included methods for defining issues, managing data, evaluating wildlife habitat, and predicting impacts.

Task 2. Comprehensively review the published North American literature regarding effects of resource development on wildlife resources.

Task 3. Identify and review unpublished literature and related data available from agencies, private individuals, industrial operators, and universities concerning wildlife resources within the study area.

Task 4. Conduct three workshops to solicit public concerns and to present the finding of this study to the representatives of the PCC.

Task 5. Review the literature on mitigation practices currently applied to oil and gas development both within and outside of the study area.

PHASE I FINDINGS

Individual reports were produced for Tasks 1, 2, 3, 4, and 5, each presenting the task findings. This section briefly summarizes the findings to of each report and provides the background information for the recommendations made for Phase II work.

Task 1

The analytic and predictive procedures reviewed in Task 1 were grouped into four categories: collaborative analysis methods, geographic information systems applications, habitat and environmental assessment methods, and population simulation models. These categories were not mutually exclusive. For example, a collaborative analysis method may also be usable to evaluate habitat or assess impacts, as was actually found to be the case. The categories were used as an organizational framework within which to conduct meaningful evaluations and comparisons between methods.

Methods were evaluated in terms of several criteria. Among them were their utility in identifying environmentally sensitive areas, in assessing impacts, and in assisting managers develop mitigation programs, three criteria outlined by the PCC at the outset of work. A broader multi-step planning process that included these three steps as well as description and assessment of area-wide resources, evaluation of development alternatives and management strategies, monitoring, and reevaluation of development and management scenarios was also used. For each category, additional criteria were added to account for applicability to the study area, difficulty and costs of application, etc.

Collaborative Analysis Methods. The collaborative analysis methods evaluated included the Delphi Method, Nominal Group Technique (NGT), PUBLIC, and Adaptive Environmental Assessment and Management (AEAM). All four methods are designed to bring individuals and organizations "together" to jointly identify and solve management and planning problems. Corollary applications include issue identification, problem definition, conflict resolution, and, to a limited extent, public involvement.

The Delphi Method and NGT have been most widely applied in business and industrial operations settings. Both are primarily intended to facilitate group analyses and decisions by using devices that control dominating person-

alities, authority figures, and hostile or argumentative individuals. PUBLIC was designed primarily as a device for incorporating public input into the natural resource management process. It can be used to determine the extent to which various interests agree or disagree on management goals and strategies and to allow an agency to accommodate the political setting in its planning practice. AEAM uses one or more workshops attended by key scientists, managers, decision-makers, and other stakeholders to develop a computer model of a natural system which contains sensitive resources whose management or modification through development has stimulated controversy and conflict. The product is a computer simulation model used to test an array of development and/or management scenarios so that the group can jointly decide on an acceptable course of action.

All four methods can be used successfully as collaborative analysis tools. Compared with AEAM, the Delphi Method, NGT, and PUBLIC are relatively inexpensive and easy to apply. At least initially, AEAM requires the assistance of outside experts familiar with running workshops, getting people to collaborate, and developing smoothly-running computer simulation models. Its computer capabilities lend no advantage in the area of collaborative analysis, but AEAM can be applied more effectively than the other three methods throughout the multi-step planning process outlined above. Therefore, it was considered superior.

Geographic Information Systems. Geographic information systems (GIS) are manual or computerized systems used for storing, analyzing, and displaying information in the forms of maps, reports, aerial photographs, etc. Computerized systems, which were reviewed in Task 1, require computer facilities and operating staff and are initially much more costly to develop than manual systems. But under heavy use, they offer considerable advantages which can make the initial investment worthwhile.

Assuming conditions would warrant its use, several feasible ways exist for employing a computerized GIS. These include: 1) contracting an outside consultant to gather the information from the three states' agencies, computerize the data base, and conduct analyses for the PCC or individual agencies as necessary over some specified contract period; 2) using either of the two operation systems available among the PCC agencies, specifically the State of Utah's system or the Wyoming BLM's system; or 3) using one of the systems available through another public institution or agency. The USFWS operates a pair of systems, either of which can support its Rapid Assessment Methods (RAM).

Each alternative can be used to conduct analyses and produce results useful in identifying environmentally sensitive areas, describing full area-wide resources in either map or textual form, evaluating alternative development scenarios (road locations, stream crossings, rail alignments, sour gas plant sites, man camp sites, etc.) and management (mitigative) actions, and in assessing graphically in a quantitative fashion the impacts of development. Some differences distinguish the alternatives, but these relate primarily to the administrative details of implementing GIS applications across state and

jurisdictional boundaries. Although these differences would be significant at a time when a choice between the alternatives became necessary, the use of a computerized GIS and exploration of the administrative implementation mechanisms are relatively secondary in importance compared with the more immediate needs of completing resource data bases and assessing the impacts of existing development and the success of existing mitigation and reclamation programs.

Habitat Evaluation Methods. The habitat and environmental assessment methods evaluated include terrestrial and aquatic methods. The terrestrial methods include the U. S. Fish and Wildlife Service's Habitat Evaluation Procedures (HEP), the Wildlife Management Information System (WILDMIS) developed at the Colorado Cooperative Wildlife Research Unit, and Wildlife and Fish Habitat Relationships (WFHR) being developed by the U. S. Forest Service. The aquatic methods include the Physical Habitat Simulation System (PHABSIM) developed by the U. S. Fish and Wildlife Service, Habitat Quality Index (HQI) developed by the Wyoming Game and Fish Department, and the General Aquatic Wildlife System (GAWS) developed by the U. S. Forest Service.

Terrestrial Methods. HEP was developed as a tool for assessing the value of an area to a species, or group of species called a guild, by subjectively rating each areal segment of habitat according to a model called a Habitat Suitability Index. The index relates existing conditions to optimal conditions for the species or guild. The product is an estimate of "habitat units", a number which can be used to compare different areas or the same area at different times, such as before and after development. WILDMIS was developed to set species production (management) objectives, evaluate habitats, assess impacts, and identify the most cost-effective management strategy. WILDMIS contains several components, the central one being PATREC. PATREC is a habitat evaluation method that employs pattern recognition and conditional probabilities to calculate the probability that an area is high- or low-quality habitat for a particular species. The product is a crude estimate of long-term mean population density for the area evaluated. WFHR is a large data base that contains regional information on terrestrial and aquatic vertebrate species and their habitats. WFHR is used in multi-resource management to characterize habitat quality, evaluate timber management alternatives, predict harvest impacts, and to develop mitigation programs. The WFHR data base has been computerized by the Intermountain Region (Region IV).

HEP and PATREC are general methods that could be applied easily to the Overthrust Belt. WFHR would be less applicable because the data base is forest-oriented and little forest exists in the Overthrust Belt. Although HEP and PATREC would be excellent for large-area habitat evaluation, none of the three methods would be a particularly good tool for identifying environmentally sensitive areas, predicting impacts, or evaluating reclamation or mitigation practices. They have not been rigorously field tested or evaluated and do not have particularly strong histories of successful application. Applications also require considerable commitments of time and manpower.

Aquatic Methods. PHABSIM was developed to simulate and quantify: 1) available microhabitat for fish species or life phases of interest under dif-

fering flow regimes; 2) water quality conditions; and 3) physical channel structures. Field measurements, computerized hydraulic simulation, and habitat suitability rating curves are used to produce estimates of weighted usable area of instream habitat over the range of stream discharges considered. HQI was developed to evaluate aquatic habitat but has been used to assess habitat improvement potential, predict standing crops, and support instream flow recommendations for salmonid species. HQI incorporates field data into one of two computerized multiple regression models. GAWS is a computerized system developed to inventory, describe, monitor, and predict habitat conditions and habitat vulnerability to land use impacts. It includes methods for conducting macroinvertebrate surveys, instream flow analyses, four levels of stream surveys; lake surveys will be added later when they become operational.

All three aquatic habitat evaluation methods are suited for application to the Overthrust Belt. PHABSIM permits better species- and lifestage-specific analyses than HQI and GAWS. Documentation is more accessible for PHABSIM and HQI than for GAWS. GAWS and PHABSIM, however, seem to be more broadly applicable than HQI. HQI yields standing crop as the application product; PHABSIM and GAWS yield unitless quality indices. HQI provides a more clearly usable end product. Programs necessary to run HQI on a small programmable calculator have been developed and are available; GAWS and PHABSIM require out-of-office analyses. HQI appears, therefore, to be the superior aquatic habitat evaluation method.

Population Simulation Models. Three population simulation models were evaluated: ONEPOP, POP50, and POSIM. Each is designed to mathematically represent wildlife population dynamics in a model typically run on a computer. All use population size, age, and sex information. ONEPOP was developed by the Colorado Cooperative Wildlife Research Unit, is written in Fortran IV, and is used in batch mode on large computers. POP50 was developed privately as an alternative to ONEPOP and was designed for use on microcomputers. POSIM was developed by the Montana Department of Fish and Game and is written in Gasp IV. All can be used to model population dynamics for species with one birth pulse annually. ONEPOP and POP50 would apply well to the Overthrust Belt but all three methods offer little utility in identifying environmentally sensitive areas, assessing impacts, or developing mitigation programs because they were not designed for these purposes. ONEPOP and POP50 have poor histories of application and POSIM's history is unknown. ONEPOP is the most accessible model and POSIM is most demanding in terms of time and manpower requirements.

Task 2. Task 2 was a review of the available literature on fish and wildlife impacts resulting from natural resource development and human activities. While the primary focus of the review was to examine documented relationships between petroleum industry development and wildlife, reported influences of road construction and use, mining, logging, aircraft, transmission lines and other structures, grazing, fire, and recreational use in wildlife habitats were included. These activities have similar effects in some respects. Effects on big game, furbearers, raptors, game birds, nongame wildlife, amphibians and reptiles, fish (and aquatic resources), and threatened and endangered species were separately discussed.

The literature search produced very little data on wildlife in the Overthrust Belt prior to oil and gas exploration. In its absence, data collected during the development received primary attention. The major conclusions are:

1. Little research has been done specifically on the impacts of the oil and gas industry on fish and wildlife species occurring in the Overthrust Belt when compared to other forms of developments or the environmental alterations associated with logging, road construction, mining, etc. However, available literature suggests that many aspects of oil and gas development are not unique in their impacts on wildlife. Habitat alteration and human disturbance to wildlife during oil and gas development occur in much the same manner as other forms of development. Information gained from impact research on logging, grazing, fire, mining and other forms of habitat alteration is useful. However, habitat use by affected wildlife populations and population response to habitat improvements are poorly understood.
2. In general, little information exists on wildlife species and the possible impact of oil and gas development on wildlife in the Overthrust Belt. Most of the studies done have been descriptive rather than experimental and those available lack adequate controls. Most have also been short-term studies. Generally, the studies have lacked testable hypotheses and/or a solid theoretical foundation. Interpretations are also confounded by inadequate sampling techniques and insufficient replication.
3. For big game, little information exists on impacts of oil and gas and related industrial development and activities. Elk movement is known to be affected by seismic activities and bears are known to abandon dens when seismic and/or construction and excavation activities are nearby. Effects of road and air access result primarily when humans leave their vehicles, but depend upon the cover near the roads and vary with species. Specific information on habitats and distribution is needed so that areas that are important, critical, or seasonally sensitive can be identified. Gaps exist in the data on effects on the welfare, survival, and reproductive potential of several species, and the vulnerability by sex and age class is unknown. Increased legal and illegal harvest, displacement and degradation of the habitat into which animals are displaced, and the population effects of displacement are unknown.
4. Except for a study on beaver near Kemmerer, Wyoming, few definitive studies exist on the effects of development on furbearers populations. The literature suggests that some arctic furbearers species are adaptable and tolerate human disturbance, but no data exists on the biology and seasonal sensitivity of species in the Overthrust Belt (wolverine, fisher, lynx, river otter, etc.) that can be used as a basis for accurate impact assessment.
5. Nesting habitat requirements for raptors in the study area are well documented but the effects of development and human activities on

raptor nesting habitat and prey bases are unknown. Population resiliency and the probability of returns to pre-impact levels are also unknown. Raptor management techniques described in the literature would be useful in transmission line support tower design, fenceline placement, and prey habitat manipulation.

6. Information on game bird, nongame, reptile and amphibian, and fish species is also limited. Insufficient information exists for accurate assessments of the effects of development on these species groups.
7. The literature emphasizes the importance of riparian and aquatic habitats in the arid west for many wildlife groups.

Task 3. Task 3 was an evaluation of the utility, or applicability, of local public knowledge of existing wildlife resources in each of the three states in developing baseline descriptions against which the impacts of development and the success of management can be accurately assessed. Raw data, analyzed data, and mapped data were evaluated. The major products of Task 3 are an annotated bibliography, which provides details on all the documents reviewed, and the Task 3 report, which summarizes the findings for the following species groups: big game, game birds, endangered species, furbearers, game fish, raptors, small game mammals, nongame mammals, nongame birds, nongame fish, and reptiles and amphibians. Information of riparian and aquatic habitats was also evaluated.

In Utah, considerable information is available on big game from the Utah Division of Wildlife Resources (UDWR), Utah State University, and the U. S. Forest Service. UDWR information is most extensive and includes harvest reports, which are compiled on a county-wide or herd-unit basis, and habitat distribution maps. Harvest reports and distribution maps contain the primary information available on game birds. The distribution maps, for example, show sage grouse leks, winter range, and breeding range. Bald eagle winter concentration areas and roosts are mapped as are hawk sites for bald eagles and peregrine falcons, but, in general, little information is available for threatened and endangered species. Harvest reports and UDWR maps contain information on furbearers such as otter, marten, and beaver. Habitat maps showing cold- and warm-water fisheries, habitat rankings, and stream classifications exist for the study area and conflicting development and protection needs are identified for game fish. The Randolph Unit Resource Analysis contains nest location and occupancy information for a portion of the study area and UDWR maps show golden eagle, ferruginous hawk, red-tailed hawk, prairie falcon, and great-horned owl nests. Limited data is available for small and nongame mammals and nongame birds and only a single document provides reptile and amphibian data. Nongame fish information is available only as additional data in game fish reports.

In Wyoming, the Wyoming Game and Fish Department (WGFD) prepares annual big game reports for each Data Analysis Unit in the state and the data is broken down by hunt-areas. Big game distribution, habitat use, and population

data are stored in the Wildlife Observation System. For game birds, only sage grouse and waterfowl information is extensive. Annual waterfowl reports are prepared and sage grouse lek, hatching data, brood production, and harvest data are available. The Nature Conservancy's Natural Heritage Program is the best single source of data on threatened and endangered species and the U. S. Fish and Wildlife Service has data on black-footed ferrets, peregrine falcons, and bald eagles. Limited data has been collected on furbearers, this by WGFD and the BLM Rock Springs District. Beaver and beaver pond, mink, muskrat, and skunk data is available as is state-wide information on bobcats. WGFD stream, lake, pond, and reservoir data and BLM stream inventory data contain information on game and nongame fish. The U. S. Fish and Wildlife Service, the BLM, and WGFD have collected raptor data on the study area. Small game mammal information is limited and among the nongame mammals, good information exists only for the prairie dog. Nongame birds have been documented in the study area by state and federal agencies. Reptile and amphibian data is most limited.

Idaho also has better information on big game than it does for most other species groups. The Idaho Department of Fish and Game (IDFG) completes annual big game harvest reports and management plans for mule deer, elk, moose, bear, and cougar. IDFG also prepares annual upland game bird harvest reports but upland game birds receive low management priority in Bear Lake County and information is limited. IDFG and the U. S. Fish and Wildlife Service jointly survey waterfowl in Bear Lake National Wildlife Refuge each summer and fall. State and federal agencies provide information on threatened and endangered species; information is best for the bald eagle. For furbearers, population estimates are available only for beaver; limited data is available for muskrat and qualitative population estimates and rough distribution maps are available for river otter and bobcats. Game fish data come from angler surveys and creel censuses. Surveys exist for the Bear Lake and Bonneville cutthroat trout but limited information is available for other game and nongame fishes. Little information is available for small game and nongame mammals and nongame birds and only habitat matrices exist for reptiles and amphibians.

In general, the data gaps are considerable for all three states and the applicability of most data is limited. The amount and utility of information is generally best but still incomplete for high-priority species such as big game, threatened and endangered, and game bird species. Information on furbearers, game fish, and raptors is intermediate in amount and quality, and information on other species groups is extremely limited and would be of minimum value for site-specific planning and impact assessment. Often, a higher level of resolution would be necessary to use the data either for site-specific planning or impact assessment. Information on the effects of changing land uses, including the effects of oil and gas and related industrial development, is generally absent.

Task 4. Task 4 provided an opportunity for members of the public to participate in the study and for representatives of the Project Coordinating Committee to review the products produced in the other tasks. Appendix A to

this report contains a summary of the comments made at the public hearing held at the outset of the project. The review comments of the PCC representatives are reflected in the task reports that follow.

Task 5. Task 5 was an assessment of methods used or proposed in a number of states by agencies, consultants, or research personnel to mitigate the effects of development on wildlife. The primary product is a comprehensive table which summarizes the measures taken to mitigate the effects of each of several component activities of oil and gas development. These components include: seismographic testing, exploratory drilling, road development and well site access, increased human activity, field development, and well site and road abandonment. Without judgements as to the reality or significance of impacts, the charts present related mitigation measures, both from oil and gas and other development. Cost data is not readily available from any source. Furthermore, little study accompanied the implementation of the identified measures to determine their effectiveness.

Man camps, seismic explosions, surface-shattering heli-drilling, and helicopter traffic could potentially displace wildlife from nest sites, and breeding and feeding areas. Proposed mitigation measures have included restrictions on camp siting, avoidance of critical habitat (calving, lambing, and fawning areas; winter range), and environmental education of field personnel.

Exploratory drilling and well siting could potentially cause direct habitat loss, displacement, and consequent reliance on sub-optimal habitat. Proposed mitigation has included restrictions on length and timing of surface occupancy, confinement of disturbance, establishment of buffers to protect riparian and aquatic habitat, and a host of off-site actions including habitat improvement through prescribed burning, seeding, off-site water development, the construction of artificial nest sites, and animal transplants.

Road and pipeline location and construction practices are believed by management agencies to cause upland and riparian zone erosion, stream sedimentation, and aquatic habitat alteration. Proper culverting, control over stream crossings, buffer zone establishment, and streambank revegetation and stream rehabilitation have been proposed to offset these impacts. Increased traffic and recreational activity potentially disrupt wildlife activities, displace animals, and increase vehicle-related mortality. Road closures, speed restrictions, increased law enforcements, and use of existing roads have been proposed to offset these impacts. Electrical transmission lines can cause raptor electrocution; line location and design modification have been employed to reduce electrocutions.

Reclamation is frequently required of companies as a mitigation practice. Specific practices have included contour (conformity) grading, terracing to control runoff, topsoil stockpiling (with controls on the length of time soil can be stockpiled), deep chiseling to loosen material and improve the potential or successful reestablishment of planted species, a variety of planting schemes involving primarily grasses and forbs but also shrubs, and compaction of fill along pipelines to prevent settlement and subsequent gulley erosion.

Withdrawals from surface and subsurface waters have caused losses in aquatic habitat and upland water sources. The use of deep aquifers not connected to streams or seep springs has been tried as a means of reducing impacts.

In general, a variety of techniques have been tried. Success has not been fully or even adequately evaluated. Cost-effectiveness has not been studied. Also, the information in the tables does not include experience from several oil producing states such as California, Texas, and Louisiana. Mitigation measures taken from the experience in these and other states could be applied to the Overthrust Belt.

METHODS

INTRODUCTION

This section contains a description of the methods used to conduct Phase I studies. Three procedures were used: literature search and review of published studies; acquisition of and review of unpublished studies specifically related to Task 3 and Task 5 objectives; and public involvement. The descriptions of methods are generalized to be inclusive. Where detailed procedures were used for specific tasks these are described in following chapters presenting the findings of each task.

LITERATURE SEARCH AND REVIEW

Search Procedures

Three major sources of publications and reports were explored for information pertinent to the effects of human disturbances on wildlife in the study area. These included: 1) computerized literature databases; 2) personal literature collections of project investigators; and 3) publications collected from state and federal agencies in the Rocky Mountain region. In the following paragraphs the search procedures employed are briefly described; however, a more extensive explanation appears in the companion annotated bibliography (see Appendix D).

The first step was a search of several commercial computerized databases available through the Bibliographic Retrieval Service (BRS) located in Scotia, New York. All searches were conducted at the University of Wyoming (UW) on computer terminals linked via long-distance telephone lines to BRS. Professional database searchers from the UW Libraries' Bibliographic Database Service helped design and conduct the searches. Citations isolated during these searches were printed off-line by BRS and mailed to UW where they were screened and classified according to their potential usefulness for the computerized bibliography and the literature review.

Because of the wide range of topics included in the Phase I study program, the computerized database search was divided into two phases. In the first phase, the files of 14 databases (e.g., BIOSIS, NTIS, ENVIROLINE) were searched to locate citations that included the full names or acronyms of analytical and predictive methods used in wildlife studies (e.g., ONEPOP, PHABSIM, AEAM). Additionally, a list of 15 general keywords and phrases related to analytical and predictive methods (e.g., systems analysis, habitat evaluation, spatial data handling, conflict resolution) was crossed with a second list of 8 modifiers to emphasize wildlife/habitat applications (e.g., environment, population, disturbance, impact) and thereby narrow the search (see Appendix D). The citations obtained were given to Task 1 investigators for screening, evaluation, and inclusion in the review of analytical and predictive procedures.

In the second phase of the computerized database search, the genera and common names for all of the species known or suspected to occur in the Overthrust Belt were compiled into a taxonomic/common name list. Next, a list of aquatic and terrestrial habitat terms and vegetation types in the Overthrust Belt (e.g., stream, riparian, water quality, forest, sagebrush) was synthesized. A third keyword list included general terms related to mitigation/reclamation procedures (e.g., impact, restabilization, reforestation, reseeding). Finally, processes and activities associated with human disturbances that may affect wildlife in the Overthrust Belt (e.g., oil drilling, construction, sweetening, pipeline, recreation, logging, grazing) were grouped into a fourth keyword list. These four keyword lists were then entered onto computer files for subsequent database searching.

BIOSIS was searched first because it contains the most wildlife-oriented citations and because it has the most convenient cross-indexing system. In this search the process/activity list was first crossed with the taxonomic/common name list of all animals, then with the mitigation/reclamation list, and finally with the habitats list. The broad range of terms included produced an excessively large number of references after the search with these initial crosses. Even by confining the references to studies performed in the United States and Canada and discarding almost all laboratory studies, the list was only narrowed to approximately 15,000 citations. Since additional search refinements were likely to exclude many useful references, this was used for preliminary screening.

After the BIOSIS search results were screened and evaluated, the AGRICOLA and DOE ENERGY databases were searched. These two additional files were chosen because they include wildlife-oriented and energy-related literature and because they were likely to supplement the BIOSIS database citations. For these searches, the taxonomic/common name list was crossed only with the process/activities and the mitigation/reclamation lists. Approximately 2,000 candidate references from each database were chosen for subsequent screening. No other databases were searched because of the limited number of useful references appearing in the AGRICOLA and DOE ENERGY database searches that had not already appeared in the BIOSIS search and in manual searches of the project investigators' personal literature collections.

An additional set of searches was conducted to augment the limited number of references relating to wildlife stress that were identified in the database searches described above. This time, the phrases "stress" and "heart rate" were crossed with the taxonomic/common name list in the BIOSIS, AGRICOLA and DOE ENERGY databases. Unlike the previous searches, laboratory studies were included in the resultant 4,000 citations.

The second major source of publications and reports was personal literature files of project investigators. Very simply, these investigators and the project technicians manually searched card files, journals and shelves for pertinent titles. Especially useful were bibliographies published by UW investigators and by federal agencies concerning individual species and the

effects of human activities on wildlife. These literature collections were the largest source of references for the Task 2 and Task 5 reviews.

The last major source of publications and reports was state and federal agencies in the Rocky Mountain region. Verbal and written requests for information specific to the Overthrust Belt produced several important documents. The files and publications lists of the Wyoming Game and Fish Department were also searched for useful reports, which were either reviewed in Cheyenne or photocopied and distributed to project investigators.

Preliminary Screening and Classification

To reduce the review coverage to a level consistent with the available time and budget, screening criteria were used to select for review and evaluation those documents that contain the most pertinent and useful information, describe superior methods, etc. The screening criteria varied task to task.

Task 1. For Task 1, analytical and predictive procedures were classified into four categories: collaborative analysis methods; geographic information and data base management systems (and their applications); habitat and environmental assessment methods; and predictive and population simulation models. The initial screening criteria used to select candidate procedures were:

1. successful documented applications to industrial and other development and/or natural resources in wildland settings;
2. history of past use and success in general application; and
3. prior use and acceptance by agencies represented on the PCC or which otherwise have jurisdictional authority in the study area.

The computerized literature searches, personal contacts, and reviews of initially available documents narrowed the field of candidate methods relatively quickly and the screening process was effectively a single-step process. As described in the chapter on analytical and predictive methods, these methods were evaluated within the context of an overall planning process and development beginning with initial collaborative analysis and terminating with post-project monitoring. In effect, application within this context was used as a screening criterion for all four categories of methods as well as a basis for subsequent evaluation.

Criteria were developed to evaluate methods and models and to select those meriting closer attention. Methods eliminated at the first received no review but citations were included in a bibliography of relevant literature. Methods carried to the second level received a brief, abstract-format review. Only methods carried to the third step or level were discussed in considerable detail. The underlying objective throughout this process was to identify and critically review a number of methods which have strong potential for application in the study area.

Task 2. For the Task 2 review of potential effects of human activities on wildlife, the first screening criterion required that a publication or report pertain to the following groups of species:

1. big game;
2. game birds;
3. furbearers;
4. raptors;
5. reptiles;
6. nongame mammals and birds;
7. threatened and endangered species;
8. fish and amphibians.

Reports dealing generally with habitat requirements were retained for review and for inclusion in the annotated bibliography.

The second criterion was reference to human activities that might affect wildlife or their habitats in the Overthrust Belt. Important processes and activities included:

1. oil and gas exploration and development (seismic, drilling, road construction, pipelines, sweetening plants, etc.);
2. logging (clearcutting, road construction, transportation, etc.);
3. grazing (competition, habitat destruction, water quality deterioration, etc.); and
4. recreation (vehicular disturbance, habitat destruction, harassment, hunting pressure, etc.).

As a final criterion, any publication or report that described species distributions or habitat characteristics in the Overthrust Belt was selected. In general, no specific information was available for the Overthrust Belt. Thus, the review included publications related to similar habitats or similar human disturbances in the Central and Northern Rocky Mountains and in the Northern Great Plains. For some less studied categories, the geographical criterion was expanded to include all of the United States and Canada (e.g., effects of logging on raptors, effects of any human disturbance on reptiles and amphibians, effects of drilling rigs and pipelines on ungulates). Geo-

graphical screening criteria were flexible and were adjusted to better estimate the amount of literature available for each category.

The computerized database printouts were screened according to these criteria and the personal literature collections of project investigators were scanned for acceptable references. Individual citations were displayed on 5 x 8 cards and filed for inclusion in the annotated bibliography. From the approximately 2,000 references in this file, pertinent citations were chosen and classified according to their importance for the above-listed groups of species and habitat characteristics. Copies of all reports and articles that could be located were then distributed to the reviewers responsible for the respective species and habitat groups for review and evaluation.

Task 5. For the Task 5 review of potential or suggested mitigation measures, similar screening procedures were used to sort the available literature on the implementation of mitigation procedures. Four general categories of mitigation were considered: 1) avoidance; 2) trade-off analysis; 3) reclamation/restoration of habitat; and 4) modification of development activities. Mitigation and reclamation procedures used within the Overthrust Belt were reviewed but because relatively little oil and gas development has occurred there, experience from other geographical regions of the United States and Canada were also included in the review.

Review and Evaluation Criteria and Procedures

Task 1. Each method reviewed for Task 1 was but one of several tools that could be used in the study area. Possibilities for joint use of methods were considered in the review and attempts were made to find examples where combinations of methods have been used.

Collaborative analysis methods and geographic information and data base management systems were evaluated in terms of their utility in a broad multi-step planning process beginning with issue identification and ending with evaluations of development scenarios and management strategies. Included in this process are identification of environmentally sensitive areas, impact assessment, and development of mitigation programs. Utility at these three steps in the process was identified by the PCC as a primary criterion against which performance of these tools was to be evaluated. Collaborative analysis methods were also evaluated in terms of the needs for outside assistance in applications, costs (absolute and/or relative) of applications, basis for obtaining participation, and the effect the sociopolitical and legal setting can have on their success. Geographic information and data base management systems were evaluated in terms of need for outside assistance, time and dollar costs of initial commitments and subsequent applications, and computer requirements (facility requirements, input, etc.). Example applications are used to evaluate the systems and to assess the utility of each system for application to the study area.

The review of habitat and environmental assessment procedures and population simulation models was conducted in two stages of increasing detail.

First, all procedures which passed initial screening were summarized at an abstract-level of detail. These abstracts are included in Appendix B. Criteria considered at this stage included:

1. relevance to species and physical characteristics of the study area;
2. level of development (accessibility);
3. usefulness for impact assessment; and
4. history of application.

Procedures were chosen for further detailed review on the basis of the following desirable characteristics:

1. previous application in Rocky Mountain region;
2. application by government agency; and
3. ability to satisfy objectives specified for the Cooperative Wildlife Program.

Task 2. For the Task 2 review of the effects of human activities on wildlife in the Overthrust Belt, one or two qualified experts from the UW staff was assigned to each of the groups of wildlife species previously listed. The goal of the review was to determine the state of knowledge concerning the effects of oil and gas exploration and development, logging, grazing and recreation on all species groups and habitats. Specifically, reviewers were directed to:

1. identify where adequate information is available for scientifically sound decisions concerning impact avoidance or mitigation of human activities;
2. identify gaps in the scientific understanding of potential impacts caused by human activities in the Overthrust Belt and identify gaps in knowledge of the flora and fauna potentially affected by these activities; and
3. recommend research priorities to increase understanding.

As noted previously, highest priority for review was given to studies conducted in the Central and Northern Rocky Mountain regions. Results of these investigations may most easily be extrapolated to the Overthrust Belt. However, for less studied species (e.g., reptiles, amphibians, nongame birds, etc.), the effects of similar activities occurring in other regions of the United States and Canada and the effects of human disturbance in general were sometimes evaluated for predictive value in the Overthrust Belt. Specific criteria used for evaluation of this type of information included:

1. findings were relevant to the Overthrust Belt;
2. paper discussed results of a field study;
3. baseline data were used to determine impacts;
4. data were collected during several seasons;
5. data were used to support conclusions;
6. hypotheses were posed and tested; and
7. land uses were directly correlated with observed effects.

In order to focus the review, matrices were prepared to summarize the reviewer's findings (see Appendix D). Each interaction in the matrices was considered in terms of significance, priority for investigation, status of existing knowledge, and independence. By preparing a matrix for each group of wildlife, results of the review were rapidly summarized and used to separate the effects of oil and gas development from those of other land-use activities.

Task 5. The literature review in Task 5 included papers that discussed actual mitigation practices were evaluated on the basis of technological adequacy, cost of application, wildlife response, constraints unique to the Overthrust Belt, and success in adoption by industry and public land management agencies. In an associated survey, the reclamation practices used by mining and oil and gas companies in Wyoming, Utah, and Idaho were described based on telephone interviews with company personnel. The results of this survey are reported in Appendix E.

AGENCY AND LOCAL CONTACTS

Data Collection Methods

Most information for Task 3 and some for Task 5 was collected by contacting knowledgeable individuals in the three states and elsewhere. The information was collected by a team which included LSA, UW, and the Idaho Department of Fish and Game (IDFG). For Task 3, LSA was responsible for contacting government agencies in Utah or with jurisdiction in Utah and for contacting faculty members and reviewing relevant research theses and dissertations in the libraries at universities in Utah. UW was responsible for similar contacts in Wyoming, and was also responsible for contacting industry information sources and private individuals in all three states. IDFG had responsibility for contacting government agencies in Idaho or with jurisdiction in Idaho, for contacting faculty members at Idaho universities, and for reviewing relevant academic research works in the state.

Interviews and consultation undertaken as part of Task 5 were partial and should not be viewed as a scientific user survey. This informal procedure was however, invaluable for understanding regulatory procedures.

Evaluation Methods - Task 3

Two general types of information were to be evaluated for Task 3: information specific to the study area and information collected on a state-wide basis relevant to the study area. The latter type of information included both information that is state-wide in scope and information collected elsewhere in the states that concerns species or habitats found in the study area. Information collected elsewhere in a state was subject to considerable interpretation for relevance to the study area. The amount of valuable information in these documents varies, depending on the similarity of habitats and other factors to the study area.

Screening Criteria. A set of screening criteria was set up to determine which information would be examined in detail. Documents were grouped into information classes, assigning priority to species groups, and finally determining what combinations of information and priority classes were to be evaluated. Because many of the documents encountered did not fit neatly into the various classes these screening criteria were flexible.

Documents were placed into three information classes: analyzed data, raw data, and maps. Analyzed data was defined as information collected, analyzed, and used to yield conclusions for wildlife management. Some local management policy documents that are used for management purposes were included in this category regardless of the type and quality of data upon which they were based. Examples of the analyzed data category are unpublished scientific papers, reports, theses and dissertations, and environmental documents. Raw data was defined as documents which have not yielded conclusions or studies in progress. These included annual censuses, field notes, stream surveys, and anecdotal information. Maps were classified as habitat maps (including vegetation maps used for wildlife management), species distribution maps, and aerial photos.

Species groups were placed into three priority classes. Class 1 included big game, game birds, and endangered species. Class 2 consisted of furbearers, game fish, raptors, and riparian and aquatic habitats. Documents about small game, nongame species, reptiles, and amphibians were placed in Class 3.

The final screening was determining what combinations of information classes were to be evaluated. Priority Class 1 (species group) documents were evaluated regardless of the information class into which they fit. Documents in priority Class 2 were evaluated regardless of information class only if they were specific to the study area. Class 2 documents fitting the analyzed data class were evaluated on a statewide basis, but raw data was not evaluated on a state-wide basis for this priority class. Only analyzed data specific to

the study area was evaluated for priority Class 3. Maps were evaluated only if they included the study area.

Some documents (notably environmental statements and planning documents) did not easily fit this scheme. These documents were evaluated only if they were specific to the study area.

Evaluation Criteria and Methods. Documents were evaluated by considering the quality of studies and their value to the OIA project. For analyzed data, the quality factors were study design, timing, and analysis methods. Study design evaluation addressed the type of data collected and the methods used to collect data. The methods were not rigorously analyzed, but the statements of methods allow the user of the bibliography to independently evaluate design. Obvious flaws or limitations were noted. The timing of the study was evaluated by noting its duration, again allowing independent evaluation by the user. The evaluation of analysis methods included a statement of the data reduction and statistical methods if any.

The evaluation factors for analyzed data were conclusions, the value of the document for baseline purposes, and potential for further study. Conclusions relevant to wildlife management in oil and gas development areas were identified. The value of baseline data depended on its utility in measuring impacts. The evaluation of the need for further study was in part based on subjective judgment. If follow-up studies were recommended in the document these were noted, but in most cases this item was a subjective evaluation of the applicability of the study and the conclusions to the problems of wildlife management in oil and gas development areas.

Raw data quality factors were similar to those used for analyzed data. Design was evaluated in the same way, and timing was also evaluated in the same way if the studies were complete. An anticipated completion date was noted for studies in progress.

The evaluation factors for raw data were similar to analyzed data factors. The value for baseline purposes and the potential or need for further study were evaluated in the same way. The geographic area covered was noted for raw data documents. An evaluation of the potential for use in wildlife management was also made which considered relevance to management needs, repeatability, and similar factors.

Maps were evaluated differently than analyzed and raw data. Quality factors included the resolution of the map, verification, and timing. Resolution was expressed as minimum polygon size (often determined by the area of a circle with the radius of the sharpest curve), minimum width of migration routes, or, in some cases, minimum cell size. Resolution should not be confused with accuracy, which can only be determined by field checking. Resolution can be used to compare the level of detail in maps, which is usually indicative of overall quality and accuracy. When possible, statements of the methods used to generate maps, such as aerial photos, ground observation, or radio telemetry were also included in the evaluation of quality. Verification

or ground checking, and the number of years of ground truthing were also noted as quality factors. Finally, the number of years of data incorporated into a map was treated as a quality factor.

Evaluation factors for maps were the scale, area covered, and the habitat types or species included. The scale of maps and area covered are usually fixed, but maps which have been digitized and placed in a computer geographic information system can be "windowed" to show any part of the map desired at a variety of scales.

For aerial photos the scale and date were noted. The type of photo, such as black and white, color, or infrared was also stated.

Information Gathering Methods - Task 3. The first step was a preliminary, informational contact by phone. In this contact, the consultants described the objectives of the project (as discussed above) to give the contact background and guide the data acquisition. The contact person was advised that only documented (but unpublished) information, as opposed to personal knowledge, was to be evaluated. The contact was informed about the types of information that would be gathered during a personal visit, but where only limited information was available, the contact was asked to mail the information.

Based on initial contacts, some library research occurred at the University of Wyoming, at the University of California at Berkeley, and at universities in Utah. Card catalogues, government documents sections, dissertation abstracts and indices, and similar sources were checked. Some documents were obtained for evaluation from these sources. In many cases, bibliographies from documents acquired at libraries were used to prepare lists of documents to be obtained or to illustrate the types of information desired from contact people.

Personal visits were made to acquire or evaluate information. Notes from the preliminary contact and lists of documents from bibliographies were used to determine the documents and types of information to be collected. If copies of documents were not available, they were evaluated at the contact person's office. If possible, copies of documents were obtained for evaluation in the consultant's home office. The contact person was also asked for leads in obtaining further information during this meeting. The conversations were summarized on interview record forms.

PUBLIC INVOLVEMENT AND PCC REVIEW

Task 4 of Phase I was conducted through a public workshop and three meetings with the PCC. The workshop and the first PCC meeting were held in Evanston, Wyoming on September 20, 1982. The purposes of the workshop and meeting were to introduce the project team, describe the Phase I work program, seek comments on the work program from the public and PCC, and initiate a process of continued public involvement. Appendix A contains a summary of the first public workshop.

The second PCC meeting was held in Evanston on August 12, 1983, after the completion of the draft report for Phase I. This meeting included three separate sections each of which had different objectives. The first section was used for a presentation of Phase I results and was arranged to promote interchange and discussions among PCC members and study participants. The second section was designed to review the status and products being developed as part of the Environmental Awareness Program, an element of the OIA's overall Cooperative Wildlife Program being conducted in parallel with this Cooperative Wildlife Study. This section was directed towards agency staff, industrial staff, and scientists active in or interested in the Cooperative Wildlife Program. Papers on each task's findings will be presented at that workshop in order to generate peer review and critical evaluation of results.

The third section of the meeting was intended to initiate discussions regarding the focus and content of Phase II of the Cooperative Wildlife Study. This section was attended by PCC representatives and the project managers for LSA and UW. The third PCC meeting was held in Laramie at the University of Wyoming on September 8-9, 1983. The meeting had three objectives. These were to: 1) conduct a technical review of the Phase I report; 2) examine and prioritize potential data gaps identified in Phase I; and 3) to discuss and prioritize the objectives for work to be conducted in Phase II.

ANALYTICAL AND PREDICTIVE METHODS

INTRODUCTION

PURPOSE

The purpose of Task 1 was to critically review analytical and predictive procedures for their use in later phases of the Cooperative Wildlife Study. For organizational purposes these procedures were placed into four categories:

1. collaborative analysis methods;
2. geographic information and data base management systems and their applications;
3. habitat evaluation procedures; and
4. population simulation and predictive models.

These categories provided a basis for selecting and comparing procedures. Comparisons are possible among procedures in each category, but are usually not warranted or meaningful between procedures in different categories. Therefore, to supplement comparisons an attempt was made to illustrate how procedures in different categories could be used in complementary fashion.

Procedures were evaluated not only in terms of their utility in identifying environmentally sensitive areas, assessing impacts, and assisting managers in prescribing mitigation measures, as requested by the PCC, but in the context of the more encompassing planning process which occurs in the Wyoming Industrial Siting and Environmental Impact Statement processes. The steps in this process are:

1. collaborative analysis - initial involvement of other agencies and organizations and the public, joint issue identification and problem definition, and conflict resolution;
2. description, analysis, and assessment of wildlife and wildlife-related resources - including inventory design and data collection, data organization and synthesis, and data and information storage and retrieval;
3. evaluation of alternative development scenarios - including impact prediction and the generation of management and mitigation strategies for each development alternative;
4. selection of the preferred combination of development and management strategies;
5. implementation of the preferred alternative, initiation of monitoring to determine what the impacts are and how well the management strategy has mitigated the impacts of development; and
6. re-evaluation of both development and management strategies if the desired results are not obtained.

Procedures were evaluated in terms of their utility at each point in this overall process. Some procedures are useful at only one point in the process; others have broader utility.

REPORT ORGANIZATION

The remainder of this chapter consists of seven sections. These are:

1. review of collaborative analysis methods;
2. review of geographic and data base management systems and their applications;
3. review of habitat evaluation procedures;
4. review of population simulation and predictive models;
5. discussion of the potential combinations possible between procedures in each of the categories;
6. literature cited; and
7. persons contacted in the course of work.

Abstracts of useful source papers are provided in Appendix B.

COLLABORATIVE ANALYSIS METHODS

INTRODUCTION

Collaborative analysis methods are used to bring individuals, agencies, and organizations together to inform one another of the issues they believe development would raise and to define the scope of the problems it may create (and the solutions it may offer). If the parties have opposing views, decisions on how to solve problems may require that they resolve their conflicts. Collaborative analysis is, therefore, also defined here to include conflict resolution. Although initial collaboration may be the first step in the planning process, it remains important even at the end of the process because initial decisions determine what is monitored.

Single agencies or organizations may perhaps identify many of the potential issues their development or management proposals may raise, but in complex biosocial settings scoping without "outside" assistance may not produce a sufficiently broad perspective. Few agencies or organizations can see all sides of a problem. Therefore, outside assistance is often desirable.

If development has effects that are not initially recognized because outside groups or interests are not consulted, disputes can develop. Even unintentional exclusions of certain outside interests on the part of an agency or organization willing to plan collaboratively can create conflicts. Groups not originally opposed to a project can become antagonistic by virtue of being left out. NEPA makes public participation an integral part of the planning process for federal agencies, but state agencies and private concerns can also initiate collaboration on their own and benefit from outside perspectives, improved public participation, favorable public reactions, and diffusion of potentially explosive situations. For these and many other reasons, an agency, industrial developer, or a consortium such as the OIA, can benefit by including outside interests in their development or management planning process.

METHODS AVAILABLE

Many collaborative analysis methods are unnamed or are stock tools common to collaborative analysis as a discipline. They lack a particular structure, mechanical organization, and specified steps (or procedures) and more resemble a philosophical approach than a concrete method. Description of this philosophical approach is outside the scope of this study.

However, some methods have a defined structure. Among them are the Delphi Method, Nominal Group Technique, PUBLIC, Synectics, the Interaction Method (including meeting management), and Adaptive Environmental Assessment and Management.

Among these collaborative analysis methods, AEAM is judged to be the superior method. It was developed primarily for application to environmental problems and has a successful record of past applications, including indus-

trial and other development applications. It has also been used by the Wyoming Game and Fish Department and numerous governmental agencies with natural resource management responsibilities. It offers the broadest application and can be extended from collaborative analysis through a re-evaluation of development practices based on continuous monitoring. For these reasons, it received detailed review and analysis.

The Delphi Method, Nominal Group Technique, and PUBLIC are also described. Each could be used to help the user identify issues or as a supplementary tool to determine the scope and content of a computer simulation model of the type AEAM generally employs, but none is as broadly applicable as AEAM. All three are suitable for obtaining information from representatives of many interest groups, but only PUBLIC was designed as a public involvement method. On the other hand, most of the firms included in Appendix C use the Delphi Method and Nominal Group Technique as standard collaborative planning tools (Ashton, personal communication).

FIRMS AVAILABLE

Many individuals, non-profit organizations, and consulting firms can assist clients in collaborative analysis and planning. Their services can encompass conflict anticipation, consensus building, issue identification, public participation management, group problem-solving and facilitation, conflict assessment, conciliation, and mediation. The services provided vary and an individual or group should be contacted directly to determine what services are offered. In the Rocky Mountain and Intermountain area, a handful of firms and organizations can provide these services. These and firms elsewhere in the country are listed in Appendix C.

Many firms employ the Delphi Method and Nominal Group Technique. They are relatively easy to use, private organizations apply them in-house to internal problems, and little training is necessary to become facile with their use. Syntectics and the Interaction Method are used specifically by Syntectics, Inc., and Interaction Associates, but both firms train potential users through workshops and training seminars. Adaptive Environmental Assessment and Management (AEAM) is applied by Environmental and Social Systems Analysts, Ltd. (ESSA), a private firm in Vancouver, British Columbia; by AEA, Inc. and LGL, Inc., two private firms in the United States; and by the AEA Group, one of the research groups of FWS's Western Energy Land Use Team (WELUT) in Fort Collins, Colorado.

Although in-house ability to apply methods can be acquired through training, the involvement of an outside or neutral party can be advantageous for several reasons. Among these are:

1. at least initially, an institution may not have the capacity or the administrative framework that permits in-house applications;
2. neutral outside agents can be objective and impartial;

3. outside agents can improve the process because it does not appear as if the agency, planner, or project developer controls the process and is asserting its will;
4. outside agents can ensure complete issue identification and, by virtue of their objective perspective are more likely to include all stakeholders in the process.

DELPHI METHOD AND NOMINAL GROUP TECHNIQUE

These two methods have been described and compared by Delbecq and his co-workers (1975) in a manual on group planning techniques. The following descriptions are based on that work.

Both the Delphi Method and Nominal Group Technique combine judgements of several individuals and group representatives to provide a basis for making decisions that cannot be made adequately by single persons or groups. They provide the user with tools for involving resource experts, decision-makers, affected stakeholders, etc., with different training, responsibilities, and perspectives in creative statements of problems and satisfactory courses of action.

The Delphi Method

The Delphi Method was developed by the Rand Corporation to facilitate group statements, analyses, and actions without the group members having to meet face to face. It contains procedures for systematically soliciting and collating a sequence of judgements through questionnaires interspersed with summary statements and feedback. The participants include decision-makers, a staff group, and a respondent group. The decision-makers are responsible for taking the ultimate action and use the process to obtain the information they need from the respondent group. The staff group designs the questionnaires, summarizes the returns, and carries out the fundamental work required to manage the process.

The first step in the Delphi Method is to develop the statement of the question(s). In the case where some development is planned for an area and the proponent or decision-maker needs to know what other interests consider to be the important issues, one question could be: what impacts would development have? If the type of development is new to an area and the respondents do not know what the development facilities will look like, a textual and graphic description should accompany the question(s). If the situation is particularly sensitive, the proponent decision-maker or initiator of the process could have a third party develop the descriptions so that the participants perceive the problem and the process to be unbiased.

The second step is to determine what group representatives should be included in the respondent panel. To insure effective participation, the user should select respondents from groups likely to be involved in the problem of concern (or be affected by the action), who have pertinent information to share, and who are motivated to participate. Because the questions have to be

addressed to the appropriate audience, the process of stating the questions and selecting the respondents can proceed simultaneously.

Members of the respondent panel are selected through a nomination process. Nominators contacted by telephone are asked to name people or groups that should be included on the panel or who can nominate others who should. Nominators can suggest themselves or the groups they represent. Balance in representation across the scope of potential viewpoints must guide the selection. All "sides" that meet the above criteria for participation should be made part of the panel.

Once the respondents have been selected, they receive the questionnaires. The questionnaire should accurately state the question(s), contain no technical or typographical errors, be an original typed version rather than a copy, and contain clear instructions. The instructions should indicate when the questionnaire must be returned and should be accompanied by a stamped, self-addressed envelope.

When the respondents have completed the questionnaires and returned them, the staff group summarizes and analyzes the results, producing a list of the items and comments made. These are grouped into homogeneous categories for each of which a summary statement is made. These statements provide the content of a second questionnaire, which asks the respondents to review the items identified and argue in favor of or against them. If they cannot understand an item they can request an explanation. Respondents select some set number of items from the list and rank them according to their importance. Respondents also supply reasons for their rankings.

When the second set of questionnaires is returned, the staff group tallies the "votes" and summarizes the reasons for the rankings. Staff members may have to contact respondents to obtain clarification or to provide it if the respondent has indicated failure to understand certain items. If the process is continued, the review and analysis by the staff group results in a set of items that provides the content for a third questionnaire. This third questionnaire could ask respondents to review their prior responses and express their individual judgements as to their importance.

The second and third questionnaires serve as feedback reports to the panel. In their ranking and re-evaluation, the panel first learns what issues others consider important and how they ranked issues. The feedback sometimes reduces the range of rankings and causes opinions to merge toward a consensus (extreme rankings may be revised, unusual items may be omitted). This convergence must be carefully considered by the staff group because persistently extreme rankings may indicate the need to investigate a certain kind of problem apparent only to an unusually qualified expert.

The Delphi Method can continue through five or more questionnaires, but concludes with a summary report to the decision makers and the panel members. If, for example, the subject was research priorities, as it might be with the OIA's Cooperative Wildlife Study, the result could be a report identifying and

ranking tasks to be funded. If the subject is impact of development, the result could be used as input to a predictive analysis. If predictions are going to take place as part of an AEAM analysis, the product could be the set of submodels that are used in the computer simulation.

Nominal Group Technique (NGT)

NGT is a structured, face-to-face technique which involves the following sequence of steps:

1. silent generation of ideas in writing;
2. round-robin feedback from group members to record each idea in a terse phrase on a flip chart or other device;
3. discussion of each recorded idea for clarification and evaluation; and
4. individual voting on priority ideas.

The group decision is derived through rank ordering or rating.

Participants in the NGT process can be identified and selected in essentially the same manner as with the Delphi Method. Any selection procedure will suffice as long as all the stakeholders are represented. Because the meeting works best with less than ten people, several separate meetings may be necessary when the number of stakeholders and potential participants is large.

As with the Delphi Method, the process begins with a statement of the problem. Participants can be informed of the problem at the time they are selected or it can be stated at the outset of the meeting. Prior statement allows the participants to prepare better for the meeting. However, the meeting begins with the restatement of the problem, perhaps phrased as a question written at the top of a flip chart at the head of the table(s). The staff person (leader) facilitating the meeting directs the participants to list brief phrases or statements (ideas) on their worksheets without talking to other members, interrupting them, or looking at their worksheets. (The staff person or leader can participate in the meeting as a panel member or be a "disinterested" third party.)

The second step is for the leader to record the ideas of the group on the flip chart. This is done in round-robin fashion. As the members see the group's list of ideas on the flip chart, they may think of additional ideas that were not recorded. Following the round-robin, they are encouraged to speak up and have these new ideas added to the group's list.

Round-robin procedures are then used in the third step to discuss each idea in turn. The leader reads the first idea aloud, and asks the group for questions, statements of clarification, and statements of agreement or disagreement. Each group member, in turn, responds without interruption. When no further comments or questions arise for the first idea, the leader repeats the process for the second, and so on for the remainder. The purpose of the serial discussion is to enhance clarification and insure complete and balanced

participation. The leader must pace the group through the step to avoid overemphasis on a single idea and prevent addition of new ideas (since that step has passed). The result is intended to be an understanding of the meaning of each idea, the logic behind it, and arguments for and against the importance of the individual ideas.

The fourth step is a preliminary vote on item importance. The leader distributes 3x5 cards to the participants and asks them to select the items they individually consider most important. If ten items are to be considered, ten cards are handed to each participant, who then writes one important item on each card. The participants then rank the ideas, and the leader collects the cards and tallies the vote. Alternatively, the leader may use the tally as the basis for discussion to examine inconsistent voting patterns and to consider ideas that appear to the group to have received too low or high a ranking.

The process concludes with a final tally of the voting or ranking. The results can be used in similar fashion to those suggested above for the Delphi Method.

The Delphi Method and NGT differ in several ways (Delbecq et al. 1975). The most significant difference is the mechanism for participation. Each has its advantages. The Delphi Method employs the opinions of individuals that remain anonymous to one another. This anonymity prevents domination by certain individuals, and can promote aggregation of judgements on a focused issue where the stakeholders or participants are hostile and meetings would be difficult to arrange or control. Personality and group conflict are also controlled in the NGT process, but the participants must be able to agree to meet and be physically and economically capable of getting to the meeting location. The Delphi Method is also valuable where meetings are economically impossible because of limited travel funds or where other conditions make travel impossible. However, with the Delphi Method, participants must be individually motivated because they do not perform in a setting in which other people are present to stimulate and motivate them.

NGT requires less calendar time than the Delphi Method. NGT requires more time on the part of the participants but less time on the part of the staff. NGT offers a better basis for conflict resolution because it allows participants to meet face to face to clarify and discuss issues. On the other hand, the conforming behavior required of participants in NGT may reduce their satisfaction with the process. If participants are not comfortable with the format, they may contribute less than they otherwise could and the group process is diminished. This latter problem is not peculiar to NGT. It can frustrate any procedure which requires organized and controlled participation.

PUBLIC

PUBLIC was developed at Colorado State University for obtaining public participation in resource management processes. It is used to determine the

extent to which groups defined in the public sector agree or disagree on how to manage natural resources. It has different objectives than either the Delphi Method or NGT. It can be used to determine how strong the disagreement is between groups or between groups and an agency or organization proposing some development or management action.

As described by the Forest Service in its Public Participation Handbook, PUBLIC satisfies the requirements placed on the Forest Service by the National Forest Management Act (Section Six) for involving the public in the formulation of alternatives. The following description is summarized and paraphrased from the Public Participation Handbook (USDA Forest Service, no date).

PUBLIC is a two-step procedure. The first step is to collect information on the perspectives of the groups with a stake in the process and the implementation of any development or management alternative. The second is a quantitative analysis of that information.

The process begins with an announcement of the intent to conduct a PUBLIC analysis. The process can handle up to 50 participants and the user must decide which interest groups should be represented. The Forest Service advises its own staff that all concerned interests be represented. If the purpose is to consider land use alternatives, the participants would be asked at the outset to rank land uses according to importance. In the case of most publicly owned lands, these uses include watershed management, wildlife management, visual resource management, developed and undeveloped recreation, wilderness recreation, mining and other subsurface resource development, and wilderness. The list offered to the participants for their ranking can include uses they themselves identify.

Once the participants have completed their ranking, the data are collected and quantitatively analyzed. A statistical test is used to obtain a mathematical coefficient which expresses the level of agreement or disagreement between the participants on the importance of each land use, issue, etc. The next step is to determine which ranking is "least disliked". The Forest Service considers the least disliked ranking to have the greatest opportunity for political survival.

Next, standard mathematical factor analysis is used to identify those participants who are relatively closely allied in their viewpoints as indicated by their rankings. The result is used to determine which participants should be placed together to jointly develop alternatives that satisfy their particular collective interests. Such groups are considered most capable of quickly developing a set of alternatives that reflects their consensus.

The next step is to have the groups textually describe their preferred alternatives. Given the range of interest groups likely to participate where development and environmental interests are at odds, alternatives such as the following could result:

1. from a group heavily oriented toward mineral production - permit mining and oil and gas development to occur at the maximum possible level while placing minimal emphasis on the preservation of visual and recreational amenities;
2. from a group of protection-oriented environmentalists - emphasize wilderness and wildlife protection, allowing timber production and mining operations to take place only where conflicts with the emphasized resources are minimal.

PUBLIC may not yield particularly novel alternatives nor be completely understood by the public. Groups formed to develop alternatives may reinforce their respective position(s) because they have not been required to compromise or resolve any conflicts in the process. They may also have difficulty accepting the preferred alternative if it differs from the one they developed. The decision-maker has, therefore, gained little in the way of conflict resolution or consensus on a development or management alternative. As a result, PUBLIC may not only identify problems, but create others as well.

PUBLIC can, however, assist the developer or proponent organization obtain public input into the development of a range of alternative courses of action and can be a valuable tool in that regard. If the groups requested to develop alternatives are clearly distinguishable, the possibility exists for obtaining some realistically different alternatives. PUBLIC must be coupled with other procedures to carry collaborative analysis and planning to completion.

ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT

Description of AEAM

Development and Philosophy. AEAM combines concepts, techniques, and procedures designed to assist in the development of creative resource management and policy alternatives (Environmental and Social Systems Analysts, Ltd. 1982). The development of AEAM began with work by Dr. C. S. Holling and Dr. C. J. Walters in 1970 at the University of British Columbia in Canada. The work continued at the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria, when Holling moved there. Because IIASA is an international research institute that brings scientists in various disciplines together from all over the world, work there vastly improved AEAM. Improvements have also been made at Environmental and Social Systems Analysts, Ltd. (ESSA), the primary practitioner of AEAM.

In its present form, AEAM brings together the concepts of adaptive management, systems analysis techniques, and the procedures of modeling workshops (ESSA 1982). Adaptive management is an approach taken by individuals or groups that recognize the role (however undefined) that uncertainties will play and design policies and strategies that permit flexible responses to uncertainty. The systems analysis methods are tools used to represent dynamic real-world systems in a qualitative and/or quantitative fashion. Modeling workshops are focused brainstorming efforts by participants; the efforts in

most cases are directed at collaborative development of a computer simulation model.

AEAM is based on two primary principles. First, key scientists, managers, decision-makers, industry representatives, public interest groups, and other stakeholders should all be brought into the resource management and planning framework. In AEAM, they gather at interdisciplinary workshops conducted by a team of facilitators once a problem has been recognized. Because AEAM encourages balanced participation of varied and often conflicting parties, it can promote a well-rounded treatment of the issues and create an opportunity for decision-makers to respond to crosscutting needs in an unbiased and rational manner. Because potential conflicts within interest groups or between interest groups and management agencies can be identified early on, possibilities for compromise and resolution are created well in advance of decision deadlines.

Second, computer simulation modeling and other systems analysis techniques promote interdisciplinary communication among workshop participants and provide the capacity to limit the scope of the problem to relevant variables. They help identify gaps in data and conceptual understanding that must be filled and eliminated if the resulting decisions are to be informed and rational. Computer simulation, which AEAM practitioners use almost exclusively, provides a rapid way to predict the potential impacts of a wide range of development alternatives and to test the consequences of management strategies used to mitigate them.

The AEAM concepts, methods, and procedures are not unique except in their combination and the attempt to apply them jointly to natural resource-related problems. The individuals who practice AEAM and facilitate applications must also possess a unique combination of skills. The facilitators must have computer programming skills, a systems analysis perspective, and the capacity to work with sometimes antagonistic people to satisfy their common needs (Andrews, personal communication).

The AEAM Workshop. An AEAM application typically requires two or more workshops. It begins with a scoping workshop attended by the facilitators (which can number six or seven), the process sponsor (usually the agency which has requested the application), and the process sponsor's staff. The scoping workshop is used to define the responsibilities of the parties involved, to place preliminary limits on the scope of the problem, to brief the facilitators on the problem and issues, and to identify desired participants. A date is also set for the first workshop that the full group of participants will attend.

Between the scoping workshop and the first workshop, logistical preparations are made, participants are contacted, and the computer hardware and software are set up and tested for the modeling activities. The facilitator team and the process sponsor staff review available data to prepare prior to the workshop.

Thorough planning and preparation are necessary because each workshop is usually only five days long. The preparation for the first workshop normally includes the accumulation of existing data. This may take place at the sponsoring agency beforehand and require little or no pre-workshop organization.

Table 1-1 shows a typical schedule for the first workshop. Following a basic introduction on the morning of the first day, the participants immediately determine how the system they will study should be defined. Limits to the geographical area are set and the planning horizon or projection interval over which development, impacts, and management will be considered are defined, usually in terms of years or decades. Resource issues and management responses are defined and the key actions and indicators are selected. Actions are the agreed-upon activities that management can undertake to manipulate the system toward some desired end. Indicators are those system variables that will be used to measure the performance or response of the system and to evaluate the success of the actions.

On the second day, issues, actions, and indicators are grouped into components and the participants are organized into subgroups. With the assistance of a facilitator, each subgroup will develop a computer submodel based on the issues, actions, and indicators placed into their respective component. The links or interactions between the indicators and actions in each component are conceptually determined and the information necessary to run the submodel and to characterize the interactions between the various submodels (usually there are three or more) is identified. The mechanism used is called the "Looking Outward Matrix." It cleverly requires each subgroup to ask what kind of information (output) other subgroups need from it to run their submodels. The approach is one of "what do you need from us" rather than "we need this from you". This accommodating approach encourages workshop participants to look carefully at the kinds of information they can reasonably expect from others and breeds a cooperative spirit and interdisciplinary communication. It is particularly effective because AEAM frequently brings together interests that have been at odds over resource issues.

On the third day of the first workshop, subgroups initially continue to work separately. They define the interactions and links left undefined the preceding day and continue to define the functional form of the relationships to be modeled. Information review continues as necessary into the afternoon, at which time the facilitators begin to transform the conceptual models into computerized models.

The fourth day begins with a subgroup discussion of submodel structure and its programmed form. When these discussions have concluded, the whole group reconvenes and the facilitators describe and explain each submodel and the relationships between them. Although the links between the submodels were identified on the first day before the group was divided up, subgroup work normally results in some redefinition of the linkages. If redefinitions have been necessary, the facilitators will have made the necessary changes. The afternoon of the fourth day is devoted to constructing extreme management

TABLE 1-1. TYPICAL SCHEDULE FOR THE FIRST FIVE-DAY AEAM WORKSHOP¹**First Day**

- A.M. -Overview of workshop goals and objectives
 -Introduction to AEAM workshops
- P.M. -System definition
 - Delineation of resource issue and management responses
 - Definition of key actions, indicators, state and driving variables, space and time characteristics of the problem

Second Day

- A.M. -Subdivide the resource issue into components and the participants into subgroups
 - Define interactions between components
 - Determine information each subgroup needs to supply to other subgroups
- P.M. -Subgroup meetings
 - Define interactions between variables
 - Select relationships to be modeled and define their functional form

Third Day

- A.M. -Continue subgroup meetings
- P.M. -Participants gather information needed in submodels
 -AEA facilitator staff begins programming

Fourth Day

- A.M. -Subgroup meetings
 - Discussion of submodel structure
- Reconvene workshop
 - Presentation of submodels for group discussion (Report back to facilitator staff any changes that need to be incorporated in the submodels)
- P.M. -Reconvene workshop
 - Participants construct extreme management scenario and qualitatively predict response of indicators
 - Discuss key research and policy questions
 - Subgroups meet to test and evaluate the behavior of their submodel
 - Integrate submodels into system model, test scenarios (facilitator staff)

Fifth Day

- A.M.
- Display and discuss scenarios
 - Compare model responses with participant predictions
 - Test additional scenarios suggested by participants
 - Discuss information needs and establish responsibilities for research, policy analysis, model revisions, etc.
 - Evaluate workshop and workshop staff
 - Adjourn

¹Source: USDI Fish and Wildlife Service, 1982. Quick response support to FWS for conducting adaptive environmental assessments. Request For Proposals FWS-9-OBS-82-028.

scenarios and attempting to qualitatively predict the responses of the selected indicators in each submodel. Thereafter, subgroups meet again and test the submodel to determine the reality of the behavior found in response to the extreme scenarios. Finally, submodels are integrated and tests are run using the complete model.

On the last day of the workshop, the participants discuss the scenarios, the similarities or differences between the outcomes (indicator responses), their preconceived ideas, and the information needs that the tests point out.

Work continues if there is to be another workshop. Between workshops the facilitator staff refines the model as a result of work that takes place in technical meetings. Participants collect data necessary to fill the gaps in the model. The staff prepares for the next workshop, setting objectives and, if other participants are to be invited, contacting them and advising them of the state of the process.

Subsequent workshops are generally similar. However, the objectives usually differ and the models are typically more sophisticated than they were at the end of the first workshop. Testing continues and the emphasis is shifted toward policy analysis in some cases. Data collection and evaluation of management practices may have begun in advance of the second workshop and can continue beyond it to provide information on the success of strategies. The process eventually ends with whatever products were agreed upon as a part of the contract with the facilitators. Contracts often include training so that the process can be continued with "in-house" facilitators who are more familiar with the issues and problems in the area. Reports are prepared, models are transferred, etc., but the actual products depend on the type of applications.

Evaluation of AEAM

AEAM has been evaluated by both facilitators and clients in special workshops and symposia held specifically to assess the successes and failures in applications (International Institute for Applied Systems Analysis 1979, ESSA 1982). The resulting proceedings offer a balanced but general portrayal of how AEAM works in practice. Interviews with members of WELUT's AEA Group also provide general evaluations. But example applications provide a vehicle for specific, detailed evaluations of the approach. The workshop proceedings, interviews, reviews of example applications, and contacts with clients in those specific applications were combined to obtain a complete evaluation of AEAM. This section contains a general evaluation accompanied by brief descriptions of the successes of and difficulties encountered in specific example applications.

Both practitioners and users believe that AEAM can be used for a wide range of purposes (ESSA 1982; Andrews, personal communication). These include: 1) to identify issues and unknowns and to determine which are significant and which can be ignored; 2) to enhance communication by providing an

open, coordinated assessment process; 3) to synthesize information, identify important relationships, and allow an integrated, prescriptive rather than a descriptive analysis of impacts; and 4) to facilitate evaluation of alternative development and management options.

Resource management and planning applications focus on the development and evaluation of alternative development scenarios and management strategies. The workshop environment is an excellent setting for both. Computer simulation modeling permits consideration of more numerous and complex alternatives than would otherwise be possible. Practitioners believe that AEAM stimulates the participants to think in "modes that they rarely use and thereby enhances the possibility that interesting, unusual, perhaps even creative alternatives will emerge" (ESSA 1982).

Table 1-2 shows the frequency and success of applications of AEAM to seven types of objectives. AEAM has been most successful in opening communication lines and keeping information flowing between interested parties. Attempts to identify issues and unknowns, synthesize information, plan research, and analyze policy have also succeeded. However, AEAM was considered generally ineffective in project management.

Mr. Stanley Dempsey of AMAX Corporation in Golden, Colorado, offered an industrial perspective on AEAM at an IIASA seminar on AEAM. Mr. Dempsey (Dempsey 1979) believes that the "study everything" approach has unfortunately focused more attention on baseline studies than on the relationships between parts of ecosystems. The results, according to Dempsey, have been "massive collections of disjointed facts which have little usefulness". AEAM focuses more on relationships (Looking-Outward Matrix, submodel links) and the analysis of impacts and alternatives and prevents such outcomes. Consequently, it permits improved environmental analysis and impact assessment.

One of the key tenets of AEAM is flexibility and the ability to plan in the face of uncertainty. Dempsey favors AEAM because, while it is not intended to design all uncertainty out of a project, it helps users develop the ability to absorb small failures and adjust, to be safe in failure.

The success of an application cannot always be determined by the end of the series of workshops. The appropriate evaluation period depends on the type of application and the scope of the project. Research planning success could be evaluated in a few months. Success in resolving conflict and in identifying and implementing development and management strategies could require several months to years. Assessments of the accuracy of the predictions and the ultimate value of the model may take several decades. However, most AEAM applications have been relatively recent. Few applications began over ten years ago and the average period (based on 29 applications) since the initiation of an AEAM application is approximately 2.5 years.

AEAM was not intended to be a vehicle for involving the public at large. However, many applications have included members of the public and nothing

TABLE 1-2. FREQUENCY OF USE AND SUCCESS OF AEAM BY OBJECTIVE¹

OBJECTIVE	FREQUENCY OF USE	EVALUATED BY USER ²
Identify issues and unknowns	frequent	successful
Identify impacts	moderate	moderately successful
Communication	frequent	highly successful
Synthesize information	moderate	successful
Plan research	moderate	successful
Analyze policy	infrequent	successful
Manage project	infrequent	ineffective

¹Source: ESSA Environmental and Social Systems Analysts Ltd. 1982. Review and evaluation of Adaptive Environmental Assessment and Management. Published by Environment Canada.

²Practitioners and users both rated AEAM according to objective. In most cases over half of the individuals making the ratings were users. Therefore, favorable practitioner bias (supporting your own team, blindness to faults apparent to users, etc.) would not seem to operate. However, those rating AEAM could choose between three categories that are generally favorable (highly successful, successful, moderately successful) and only one that was unfavorable (ineffective). This choice did not allow raters to adopt a neutral position. Unless they thought AEAM was ineffective they were forced to rate it as successful in one way or another.

prohibits adaptation to accommodate heavier public participation. One argument against large-scale participation (ESSA 1982) is that large modeling subgroups tend to be inefficient. Practitioners perhaps believe that few members of the public could be added without eliminating the "experts" or creating unwieldy groups. Practitioners and users also stereotypically characterize public representatives as "stubborn, uncompromising, and irrationally committed to biased and extreme points of view" (ESSA 1982). Bias against public participation could possibly be overcome by screening potential public participants, perhaps through a nomination process similar to that used in the Delphi method, and adding to the workshop group only those individuals that can competently represent the public.

Practitioners and users recognize several forms of institutional difficulty in using AEAM (ESSA 1982, Baskerville 1979). AEAM may not work well when one agency or interest group "holds all the cards" and need not compromise or resolve conflicts to meet its objectives. Such agencies or groups may be relatively inflexible and unwilling to accommodate the positions of others. Agencies that favor stability-oriented management and use a "steady-as-she-goes" approach may consider adaptive management a destabilizing threat. Institutional programs that have failed and are subject to criticism in the AEAM process can cause their authors to withhold their support or refuse to participate.

Example Applications

Three example applications of AEAM are presented below. AEAM was used by the Platte River Forum For the Future on the Platte River in Nebraska, the Wyoming Game and Fish Department and other agencies in the Jackson Hole area of Wyoming, and the USGS and other agencies in the Truckee and Carson River basins at the Nevada-California border near Lake Tahoe.

Jackson Hole Resource Development and Management Assessment. Jackson Hole Wyoming was historically an agricultural area but its scenic qualities and abundant wildlife populations attracted tourists and spurred recreational development.

Recreational development has caused some wildlife management problems. Although most of the surrounding area is federally owned, different agency goals (FWS, USFS, Wyoming Game and Fish Department, National Park Service) have created management problems on big game summer range. Big game herds are forced onto very limited winter range and migration corridors pass through or near private land. Jackson Hole also provides nesting habitat for nearly one-quarter of Wyoming's resident bald eagles and all of it is vulnerable to private development.

Development pressure is making continued agricultural use very difficult. Recognizing that continued growth could threaten the scenic and wildlife values and that previous attempts to agree on management principles and actions have had only limited prior success, the Wyoming Game and Fish Department elected to use AEAM (Andrews et al. 1981) in 1981. The objectives of the application were to:

1. promote communication among the various interests and agencies concerned with elk management in the area;
2. achieve a common understanding of the potential impact of a variety of agency policies on elk management;
3. increase awareness of the relationships between population growth, recreation, and energy development, and the management of elk and other wildlife species; and
4. identify promising alternative solutions to the elk management problem.

Representatives of the Wyoming Game and Fish Department, National Elk Refuge, Grand Teton National Park, Bridger-Teton National Forest, Teton County Planning Commission, Jackson City government, outfitting and ranching industries, Jackson Chamber of Commerce, and the local environmental community (Jackson Hole Alliance) were invited to attend. Town administration attendance was minimal and its contribution was negligible (Bartschi, personal communication; Cowee, personal communication; Hocker, personal communication).

The results of the application were mixed. In its post-workshop evaluation, the WELUT facilitator team concluded that (Andrews et al. 1981) inadequate links in the human growth submodel, untested assumptions and inadequate data for the elk dynamics submodel, and poor spatial resolution weakened the products of the simulations. Also, map overlays such as a geographic information system could supply would have been very valuable when used in conjunction with the simulation model (Andrews et al. 1981).

Nevertheless, the application of AEAM improved communication between the agencies that manage elk and the various interest groups in the area and created a common understanding of the potential impacts agency management policies could have. Participants gained a better appreciation of the relationship between energy and recreational development, population growth, and their joint effects on big game and other species. Non-agency participants emerged with an idea of the wealth of information that the agencies use to make management decisions (Cowee, personal communication) and developed a favorable impression of agency capacity.

The improvement in communication should not, however, be overestimated. Mr. Don Bartschi, Branch Chief, Fisheries and Wildlife, Bridger-Teton National Forest and Mr. Dan Cowee, Teton County Planner, however, pointed out that scenario testing in the context of the workshop is not threatening and would not stimulate the kind of conflict that actual implementation of a management alternative would. Furthermore, little conflict existed beforehand because residents of the Jackson Hole area generally value its wildlife and the other natural attractions. Therefore, until some actual plan to restrict development opportunities on private land is in the works, the disagreement among groups will not reach its full expression.

No new promising alternatives were identified for the elk or other species. According to Mr. Don Bartschi (Bartschi, personal communication),

the agencies already had a good start and new solutions could not really have been expected. Wildlife biologists and managers of the Wyoming Game and Fish Department, the USFWS, the National Park Service, and the Bridger-Teton, Targhee, and Shoshone National Forests meet annually in the Cooperative Jackson Hole Elk Management Group and thirteen years of formal and informal interaction has not produced new alternatives.

As an interesting aside, although the Wyoming Game and Fish Department uses the ONEPOP big game population simulation model in its game management programs, the model was not incorporated into the AEAM model for two reasons. First, ONEPOP was too detailed relative to the other submodels. Second, it does not account for herd migration and, therefore, could not be applied to one of the primary subjects of analysis.

Truckee-Carson Rivers Water Quality Assessment. In 1978, the USGS initiated an effort to identify the most significant resource management problems in the Truckee and Carson River Basins. To do this it had to analyze existing data and collect the additional data necessary to rationally assess these problems (Andrews et al. 1980).

The Truckee and Carson Rivers originate in the Sierra Nevada Mountains and flow east downslope into Nevada. Lake Tahoe is the major natural water storage facility on the Truckee River but several smaller diversion structures and dams alter the natural flow regime. The only major water storage facility on the Carson River is Lahontan Reservoir. Water is conducted from the Truckee River to the Carson River via the Truckee Canal.

Both water quality and quantity are important throughout the two river systems. The Stillwater Wildlife Management Area occurs at the end of the Carson River. The Fernley Wildlife Management Area is situated between the Truckee and Carson Rivers east of the Truckee Canal. At the end of the Truckee River, Pyramid Lake (in the Pyramid Lake Paiute Indian Reservation) surrounds Anaho Island National Wildlife Refuge. The endangered cui-ui and the threatened Lahontan cutthroat trout reside in Pyramid Lake and in the past spawned in the Truckee River. Anaho Island supports many avian species including a breeding colony of white pelicans.

Water demands are placed by agricultural, municipal, and industrial users, and by Pyramid Lake and wildlife management interests. Agricultural demand is heaviest upstream of Pyramid Lake and the two refuges. Population in the area, particularly Reno, has grown enormously and municipal and industrial users now sharply compete with agricultural users. The Paiute Indians have historically relied upon the cui-ui and the cutthroat trout for food. Sufficient flow must reach the Lake to permit these fish to enter the Truckee River for their annual spawning runs. At the end of the line, Stillwater and Fernley Wildlife Management Areas compete for water with the Pyramid Lake interests. The water level in Pyramid Lake has been lowered 80 feet over the years and continued lowering will create a land bridge to Anaho Island, offering new access for predators, exposing the pelican colonies to terrestrial predators.

Water quality issues are the establishment of relevant standards and waste-water treatment and disposal alternatives. Conflicts exist over both. Wildlife interest groups argue that high water quality standards must be met in the Truckee River to insure the reproduction and survival of the cui-ui and the cutthroat trout and in the Carson River to protect the cold- and warm-water fisheries. Stringent existing standards have been challenged because evidence suggests that variables other than water quality may control reproductive success and because other interest consider the standards too stringent given the area's historical devotion to agricultural production (Andrews et al. 1980).

In this situation, the USGS River Quality Assessment Team decided to use AEAM and turned to WELUT for assistance. Aided by ESSA, WELUT conducted two workshops and a series of intervening technical meetings.

The objectives of the first workshop were to rank the pertinent water resource problems, identify potential management responses to the problems identified, identify critical informational needs, and establish effective and continuing communication between the workshop participants and the River Quality Assessment Team. Three of the four objectives were met (Andrews et al. 1980) but the workshop did not produce a consensus as to what management responses should be considered in detail because important groups were involved in unsettled litigation.

The second workshop began with another set of objectives: to provide a forum for presenting progress of the assessment to the various interests in the Truckee and Carson River basins; to identify management options for potential exploration with the more detailed USGS water quality and flow models; and to identify components to be included in these USGS models. According to the WELUT facilitator team (Andrews et al. 1980), the second workshop achieved all three objectives.

Although facilitators and clients agree that the AEAM application was beneficial, both recognize that it was not as successful as it could have been for several reasons. First, conflicts exist between the state and federal interests, and between the Paiute Indians and the combined municipal, irrigation, and ranch water users. Key state individuals either did not attend the workshop or could not take steps that would in any way compromise their positions in the array of currently unsettled court cases (Nowlin, personal communication). The State Engineer and the Director of the Nevada Department of Water Resources, the Paiute Indians (or their representatives), and Sierra Pacific Power Company (the sole purveyor of power in the area) did not attend or were not properly represented. Also, the agency representatives that attended were technically competent and well qualified to create strong models, but many lacked decision-making authority and could not commit their agencies to certain courses of action (Crowe, personal communication).

Second, litigation made it impossible to implement any of the management alternative. No water allocation decisions could be agreed upon because agency authority, reservoir management responsibility, and water rights are all

under legal challenge. Existing policies are in question, many important related decisions have been brought to court, and new policies have yet to be set. As a result, the allocation scenarios and management actions tested in the workshops could not be implemented even if decision-makers had attended (Nowlin, personal communication). In this and similar situations, use of AEAM should await the more critical court decisions.

Third, the USGS, which sponsored the application, is not a management agency. The USGS recognized the significant gains made in identifying data needs and in communicating information to the public and between agencies and interest groups and was enthusiastic about continued (necessary) use of AEAM. However, it lacked decision-making status in the Truckee and Carson River Basins. It also lacked the funds, the mandate, and responsibility it needed to restart the process following the court settlements. Among the other participating groups and agencies none expressed an interest in sponsoring further workshops. Perhaps for budgetary reasons. Consequently, future use may not occur (Nowlin, personal communication).

Fourth, the process lacked "wise persons" that could carry the process further (Nowlin, personal communication). No agency or group of individuals emerged as understanding how and why the process should work, recognizing its future potential, and having the authority to direct rather than recommend continued use. Nowlin believes that the understanding and appreciation were there but, because of the absence of key decision-makers, the authority to direct was lacking.

The Platte River, Nebraska, Assessment. The decision to use AEAM on the Platte River resulted from a complex of events and decisions made over several years. One of these was the Little Blue Natural Resource District's request to divert water from the Platte River to the Blue River basin. The request was challenged in court, but in reversing an earlier (1935) decision, the Nebraska Supreme Court declared that transbasin transfers of water legal. This reversal stimulated a half dozen applications for diversions and transfers.

Another important event was the federal designation of a portion of the Platte River as critical habitat for the federally endangered whooping crane. A previous suit had been brought by the State of Nebraska and the National Wildlife Federation against Basin Electric Power Cooperative who planned to divert water for power projects near Wheatland, Wyoming. As part of the legal settlement, the court established the Platte River Whooping Crane Habitat Maintenance Trust (PRT) and made it responsible for maintaining habitat for the whooping crane and other waterfowl.

The new federalism that requires state cost-sharing for water project development also encouraged the use of AEAM. Finally, State officials wanted to use a process that resolves conflict and builds a consensus as the basis for supporting water development and water use decisions.

Before the AEAM application began, the Platte River Forum for the Future (PRFFF) was set up as the organization responsible for conducting the process. PRFFF membership includes scientists and technical experts, policy makers, water users, and environmental organizations. Three State Senators, the Director of the State Water Resources Department, the Natural Resource Districts, representatives of the Governor's Office, the Director of the Water Resources Center at the University of Nebraska, the Sierra Club and the Wildlife Management Institute, the Platte River Trust, the Central Nebraska Public Power and Irrigation District and other utilities, and members of the stock grower's associations and irrigation districts belong to the PRFFF and have participated in the first workshop conducted in August, 1982.

The objectives of the application are to create a computer model of the Platte River basin, to develop a set of new options for using the Platte River and Platte River water, to train a team of Nebraskans to use the model and to conduct AEAM workshops, and to develop a general consensus on how best to use Platte River waters in the future (Nebraska Natural Resources Commission 1982). As part of the effort to develop the AEAM model, the PRFFF will describe the effects of changing uses of water on irrigated crop yields, wildlife habitat, power generation, etc. It will also analyze the water requirements of existing users and identify options for improving the efficiency of current uses and for allocating the remaining water to new users.

At this date, only the scoping meetings and the first workshop have been held. Forty-three individuals attended the first workshop and developed a crude simulation model, thereby fulfilling one of the primary objectives. By focusing attention on the model, communication and the understanding of others' perspectives and needs have significantly improved (Vrana, personal communication).

Technical meetings are planned to refine the model in preparation for the final workshop involving WELUT personnel. This final workshop, scheduled for late 1983, will be a policy-level workshop. Following that workshop, the state's PRFFF team will assume responsibility for upgrading the model as better information becomes available and using it as a tool in deciding water use.

Although the process is still incomplete, the initial effort appears successful. According to the Director of the Nebraska Natural Resources Commission (Vrana personal communication), individuals unable to communicate rationally prior to the first workshop benefitted from the "live-in" arrangement in the first workshop and developed good personal relationships which should encourage further progress.

The Platte River and the Truckee-Carson River applications occurred at different points on a legal continuum. The success of an AEAM applications will likely vary along that continuum. When the disputants in a resource conflict first recognize the possibility of conflict and have not yet assumed relatively inflexible positions or resorted to the courts, AEAM can be an efficient collaborative analysis tool. It can be used to its full potential

because court decisions do not preclude the implementation of decided courses of management. If the conflict has reached the courts, as it has in the Truckee-Carson case, AEAM will likely be less than fully successful. Upon resolution of court cases, the opportunity and/or the need to compromise may arise again. At that point, AEAM can again become a useful tool.

SUMMARY EVALUATION

The collaborative analysis methods reviewed have been evaluated by both practitioners and users. Some of the results of these evaluations have been reported above in conjunction with the descriptions of the methods. Limited comparisons among the methods have also been provided. This section, however, is intended to provide a summary evaluation and comparison, the basis for which is the set of evaluation criteria listed in the methods sections. These are: 1) utility to the PCC agencies (as stated in the RFP) in identifying environmentally sensitive areas, assessing the impacts of development, and in assisting managers develop programs to mitigate those impacts; 2) applicability throughout the multi-step planning process outlined in the introduction to this chapter of the report; 3) difficulty in application and the need for outside assistance; 4) costs of application; 5) time required for application; 6) compatibility with other analytical and predictive methods.

As indicated at the outset of this chapter, AEAM is considered to be the superior of the four collaborative analysis methods. Table 1-3 presents the summary evaluation and comparison in tabular form.

Any of the four methods could be used to collaboratively identify environmentally sensitive areas in the Bear River Divide, the Overthrust Belt, or other areas in the three states subject to oil and gas and other development. Each could also be used to rank relative sensitivity and to assign priorities for expenditures of time and money to better characterize the resource conditions in the sensitive areas identified. However, none of these methods is necessary for such identification or ranking and AEAM would be a particularly poor, costly, and inefficient method if these were the sole purposes for using it. AEAM gains an advantage over the other three methods because its computer simulation approach allows the interactions between development and management actions and selected resource indicators to be modeled quantitatively; this capacity allows potentially more rigorous assessment of impacts and mitigation programs undertaken to minimize or avoid those impacts. PUBLIC is least useful but must be recognized as a tool not developed to assess impacts and develop mitigation programs. The Delphi Method and Nominal Group Technique (NGT) are intermediate in their utility. The Delphi Method and NGT would have to be coupled with techniques not inherently part of them to offer the same advantage.

AEAM appears to be more useful in terms of the multi-step planning process, which includes the identification of environmentally sensitive areas, impact assessment, and mitigation. All four methods are designed to provide a basis for issue identification, problem definition, and collaborative analysis

TABLE 1-3
SUMMARY EVALUATION AND COMPARISON OF COLLABORATIVE ANALYSIS METHODS

Evaluation Criteria	Delphi Method	Nominal Group Technique	PUBLIC	AEAM
Utility in meeting PCC objectives:				
Identify environmentally sensitive areas	High	High	High	High
Assess development impacts	Moderate	Moderate	Low	Moderate to High
Assist in development of mitigation programs	Low to Moderate	Low to Moderate	Low	High
Utility in overall planning process:				
Collaborative analysis	High	High	High	High
Description and assessment of wildlife resources	Low	Low	Low	Low
Evaluation of development and management alternatives (impact assessment)	Moderate	Moderate	Moderate	High
Selection of preferred development and management alternatives	Moderate	Moderate	Moderate	High
Project monitoring	Low	Low	Low	Moderate
Reevaluation of development and management alternatives	Low	Low	Low	Moderate
Difficulty in application and need for outside assistance	Low	Low	Moderate	High
Costs of application	Low	Low	Low	High
Time required for application	Moderate	Low	Low	Low to High
Number of applications ¹	Many	Many	Unknown	29
Success in application	High	High	Unknown	High

¹The Delphi Method and NGT have been applied hundreds of times. The number of Forest Service applications of PUBLIC is unknown. By 1981, AEAM had been applied 29 times.

between companies, agencies, organizations, and individuals. As indicated above, they are relatively comparable in this regard.

None of the four methods need be used to describe or assess the state of wildlife resources in a selected study area. Each can be used to draw information together into a description but for large areas the task of description generally requires other types of method or tools. However, AEAM requires participants to restrict their attention to solely those indicators and selected development and management actions incorporated into the simulation model and can, therefore, serve a beneficial purpose in focusing data collection and resource description efforts. The Delphi Method, NGT, PUBLIC, and AEAM can all be used to focus efforts, but only the latter has that purpose as a built-in, inherent purpose of both its development and application.

Once an information base exists, any of the methods can be used to evaluate alternative development scenarios or management strategies. AEAM possesses greater utility than the others because its computer simulation capacity allows many more alternatives can be evaluated in the same amount of time. As a direct consequence, it also possesses an advantage over the others in the selection of preferred alternatives. None of the four methods offers particularly strong advantages in monitoring but AEAM may be a better tool for reevaluating development and management strategies. By virtue of its advertised creation of adaptable and flexible planning, AEAM would be most amenable to reevaluating and modifying development and management practices. Well-entrenched but ineffective forest pest management practices in Canada have been drastically improved following reevaluation using AEAM but, because AEAM possesses no long-term track record, no strong statement can be made in support of its utility in this regard.

In terms of the difficulty in application, Delphi Method and NGT are superior because they require the least outside assistance or training. In-house personnel in almost any agency or organization can run the process and/or conduct the meetings. PUBLIC may be slightly more difficult to apply if the facilitator does not understand mathematical factor analysis. AEAM is, by far, the most difficult of the four methods to apply. Facile ability with computer equipment and simulation expertise are required. Although AEAM is not advertised by its developers as relying on computer simulation, almost all applications have incorporated it. Any simulation language can be used to create a computer simulation model, but the language currently used by WELUT in its applications is relatively obscure. Unless an agency or organization has access to computer equipment and has a computer expert that can do simulation modeling and can work well with people, it would find AEAM an extremely difficult if not impossible method to use. In defense of the method, the Platte River Forum For The Future has received training from WELUT and will eventually assume responsibility for running the model and all AEAM applications. Its long-term commitment to AEAM will minimize the disadvantages of application difficulties.

Costs of applications vary considerably between the four methods. Van de Ven (1974) compared the Delphi Method and NGT with non-structured problem-sol-

ving efforts of the type typically found in industry. In over 20 cases using each approach, administrators were found to require 80 to 90 hours with NGT and non-structured approaches and over 140 hours using the Delphi Method. Participants required essentially the same amounts of time to complete their participation and, on the average, contributed one and one-half hours of their time. Costs can be inferred using salaries. At rates of \$25 per hour, incorporating some measure of overhead costs, the costs of administrative time would be from \$2000 to \$2500 for NGT and non-structured approaches and \$3500 for the Delphi Method. Supply costs would be greater for the Delphi Method because of the mailings but transportation costs would be eliminated. The total costs of participation would vary with the number of participants but, in general, the Delphi Method would cost less than half that of NGT and nonstructured approaches.

The costs of an AEAM application would be an order of magnitude greater. Facilitator costs can run as much as \$80,000 without training such as supplied to the Platte River Forum For The Future. Participants must gather for a week at one or more workshops. The cost in terms of participant time, transportation costs aside, could range from \$12,000 to \$24,000 for a single workshop.

No costs are available on PUBLIC but they are assumed to be similar in magnitude to those of NGT.

Time requirements also vary considerably. Van de Ven (1974) found that NGT and non-structured approaches required four calendar days. The Delphi Method required an average of five months. PUBLIC would require something like NGT. AEAM would take at least three weeks on a fast track from the time a contract was signed engaging the services of an outside facilitator. If subsequent workshops are involved, an AEAM application could extend as long as a year. The Platte River Forum For The Future will extend its application into the indefinite future.

GEOGRAPHIC INFORMATION AND DATA BASE MANAGEMENT SYSTEMS

BASIC DEFINITION AND DESCRIPTION

Geographic information and data base management systems can be defined in several ways. John Hamill (1979) describes the GIS and DBMS which support the Western Energy Land Use Team's (WELUT's) Rapid Assessment Method (RAM) as follows:

"The GIS is used to input, store, display, and analyze map-based information. Essentially, any map, interpreted aerial photograph, or other information that can be referenced geographically, can be converted into machine-readable format and displayed and analyzed with the GIS. The DBMS is used to store, retrieve, and display textural or tabular data such as bibliographies, personnel records, inventory data, or survey data."

This functional description implies the use of a computer but applies to both manual and computerized systems. The essential difference is that manual systems require no "input" in the machine sense. Maps are drawn, reports are written, and both are stored in their original paper, mylar, etc. form. Display amounts to no more than retrieving a map from a map drawer and a report from whatever storage device is used. Analysis of geographic or spatial data includes overlaying and combining maps, summarizing the areas of different types (soil, vegetation, wildlife habitat, etc.) mapped either on a single map or one created through combination. In a manual system, all these summaries are obtained by hand using such equipment as dot grids, planimeters, and standard drafting techniques. In an automated system, these steps are all done (or can be done) by the computer. Whether or not a computer is used, the GIS and the DBMS are designed to organize acquired data and information, store it in such a way that users can efficiently update, retrieve, and analyze it, and apply it to a decision-making process.

GIS and DBMS capabilities are often combined in computerized information systems. Some GISs contain computer programs that provide data base management capabilities. In this section Hamill's definitions are used and the combination of a GIS and DBMS is referred to as an information system.

Any information system, manual or partially or entirely computerized, requires equipment, data and information, procedures and people. The equipment used depends on how automated the system is. A complete manual system could require map file cabinets, photograph storage facilities, cabinets for storing reports and other textual information; cards, catalogues, and index systems for describing the maps and reports, organizing the cards, and insuring orderly access. Back-up storage facilities and reproduction equipment may also be included. Staff persons are necessary to protect documents, update files, and assist users with both manual and computer systems (Salmen et al. 1977a).

Equipment requirements expand considerably when a system is computerized. The storage and cataloging devices and equipment generally found in a manual system are still necessary -- original documents are retained and must be stored in the same way they are in a manual system. But three additional types of hardware are necessary for a completely computerized system. These are digitizing and encoding equipment, a computer, and display and output equipment.

To conduct the desired analyses using a computerized information system, resource data must be entered into the computer in a form it understands. For example, a well location would be represented in the computer as a single pair of x-y coordinates. A stream would be represented as a series of x-y coordinates connected by arcs or straight lines. An area of vegetation would also be represented by a series of x-y coordinate pairs and arcs or straight lines which form a closed polygon. Each single record stores the coordinates of the point or the series that form the line or polygon area and the information about them (their attributes: well, stream, vegetation type). Areas can also be entered and/or stored in cell form, where a polygonal shape (a lake for example) can be represented by a series of (usually) smaller rectangular cells which collectively have approximately the same shape and area. Information on coordinates is supplied to the computer as a series of digits. A more complete description of the digitizing process and data representation is provided by Schneider and Amanullah (1979).

The second piece of hardware is a computer. Computers of a variety of sizes can be used to store geographic and textual information and to process and analyze it. They range in size from the large CDC Cyber computer at the National Oceanic and Atmospheric Administration (NOAA) facility in Boulder, Colorado, which is used by FWS, to the smaller Data General computers also employed by FWS and the state offices of the BLM.

Display equipment includes line printers, pen plotters, and alphanumeric or graphics terminals. The type of equipment used depends upon the type and use of product desired. Line printers can print maps and textual information and are cheap and relatively quick to use, but their products are less readable, not as easily interpreted, and less visually attractive than the products obtained using a pen plotter. Terminals are used to display and interactively combine and analyze maps and statistical summaries before the products and results are produced in hard-copy form.

For agencies interested in using an information system, the most important equipment for them to have is the display and output equipment. Although digitizing services are not widely accessible, digitizing can be done commercially by consultants. Large computers at other facilities can be used to store the data and the software programs necessary to do the retrieval, updating, manipulating (combining, etc.), and data summarizing. However, without display equipment, the system user cannot see what the products of his work or the results of a particular query would be without visiting another location or waiting for the results to be delivered by mail.

Computerized information systems are not inherently superior to their manual counterparts. Much of what the computer does can be done by hand; in such cases manual and computer methods are similar and the data used are essentially the same.

However, computerized systems offer several advantages over manual systems. Among the general advantages are:

1. costs of producing and combining maps and relating them to one another are significantly reduced once the original investment and time required to computerize existing data have been incurred. The high initial investment can be recovered relatively quickly if the system is easy to use and receives heavy use.
2. large volumes of data can be stored compactly, retrieved easily and analyzed quickly. Data can be updated more readily, meaning that valuable time can be spent on other more critical tasks. Furthermore, the risks associated with using outdated information can be reduced because lowered updating costs promotes continuous updating and revisions. Updating and revision becomes both painless and economical.
3. computerized systems allow agency personnel to obtain a clearer understanding of the natural resources in their planning areas than a manual system or no system at all affords (Darling, personal communication; Keating, personal communication; Bowen, personal communication; Schneider and Amanullah 1979). Analyses that were too tedious, time-consuming, or prone to error manually could be quickly and accurately done with the aid of a computer.
4. alternative development scenarios, management strategies, and potential solutions to resource planning problems can be generated and analyzed for their effects much more quickly and cheaply. Where agencies are under close public scrutiny, the ability to consider a wider range of alternatives than is possible manually offers the agency increased credibility and flexibility.

Reviews of the literature on information systems and their use by agencies and organizations with planning and/or management responsibilities (Power 1975, Schneider and Amanullah 1979) show that, for regional and larger agencies, the trend has been toward computerized systems. The increasing use of or plans to develop computerized systems by the member agencies of the PCC, by the FWS, and by other agencies in the states surrounding the Overthrust Belt show that they are following this trend.

For several reasons, only computerized systems will be discussed in this report. First, the Overthrust Belt is large and can be considered a regional geographic area. Second, many of the planning and resource management agencies interested in oil and gas and related development and its effects on wildlife in the study area now use or plan to use a computerized system.

Third, at least in Utah, lesser jurisdictions have access to and are encouraged to use the State's computerized Automated Geographic Reference (AGR) system. Counties unable to purchase their own equipment can use the State's according to a set fee structure.

Alternative ways of using computerized information systems in joint three-state planning are described below and specific applications are used to show how existing procedures and methods based on computerized systems have been used by various agencies, organizations, and consultants. Among these are the RAM applications developed at WELUT.

ALTERNATIVE WAYS OF USING AN INFORMATION SYSTEM IN BEAR RIVER DIVIDE AREA

The relevant data on the three-state area need not be organized into a single data base stored on one computer. However, if the decision is made to use a computerized information system, it would be facilitated if the data could be brought to or be made accessible from a single location (agency, facility, etc.) where a system is in operation. The problem would be to decide which location or system would be best, or how a computerized system could be made available. Several alternatives are possible, among which the most practical are:

1. a contract with a private firm to provide the necessary services using its own system, with work in the Bear River Divide area being taken on as a project.
2. use of a group use a system operational at one of the member agencies or at an outside agency such as WELUT, or public facility such as a university computer.

Alternative 1: Contract a Private Consultant

Many companies sell computerized information systems. Some also provide services on a contract or project basis using their own in-house system or one available on an outside computer. They do all digitizing work either in-house or through subcontract (such as WELUT has with Technicolor Graphics), conduct all analyses and produce all products the client specifies in the contract. Services can be provided as needed throughout the contract period.

Use of an outside consultant would have several advantages. Compared with a potentially new staff relatively unfamiliar with a new system (as is the case in Utah with its AGR), the consultant would have considerable experience and expertise with its own system and project work. The consultant would do all the work that agency personnel otherwise would have to do, a point that is important because staff time in any agency must be divided among several projects, many of which would not be related to the project area.

One of the most time-consuming tasks is encoding and digitizing map data for entry into the computer. Consultant staff or subcontracted digitizing

technicians are usually well-trained and efficient and, by virtue of their speed and accuracy, can reduce the costs and time requirements for digitizing. Also, once the contract work has been completed, the consultant can be required to deliver the computerized data base for each state to the respective PCC (and other) agencies on tapes in formats compatible with their systems' software.

This alternative also has some disadvantages. When the work is done by an outside consultant agency planners and managers are less likely to understand the system, its capacities, and limitations. They learn less about what types of products can reasonably be expected and may be reliant upon the consultant even after the data base has been transferred at the end of the contract. Also, if the consultant must juggle several projects, delays may result during periods when the consultant is overloaded.

Should the Cooperative Wildlife Study choose to use a consultant for project work in the Bear River Divide, it should consider a number of factors, including the capacity and performance of the consultant's information system, its performance on previous project contracts, and the costs of the required services. Some firms primarily install systems and provide subsequent troubleshooting support (Reed, personal communication). Others install systems but prefer to use their system on a project basis, doing most of their work for clients such as outside agencies and governments (Derrenbacher, personal communication). Few companies provide information system services without operating their own system and most firms that provide project-based services also sell and install their systems.

The focus and scope of this report preclude full description of all the firms which vend information systems and/or provide project services. Individual firms would have to be contacted to determine whether or not they would be able to provide the types of services the Cooperative Wildlife Study would need in subsequent phases.

Several reviews, however, offer comparisons of private vendors in terms of the capacity of their information systems and the quality of support they provide to clients who have purchased their systems. Among these are reviews by the Decision Analysis Group of Woodward-Clyde Consultants (Ozernoy, Smith, and Sicherman 1981) to select a system for use in their large-scale development planning and impact analysis projects, and by Calkins and Johnson (1981) to assist the U.S. Army Engineers Waterways Experiment Station automate its water data base. The analysis by Calkins and Johnson was based on their own interviews and reviews by others, including Tomlinson and Associates for the Province of Saskatchewan in Canada. The Federation of Rocky Mountain States, Inc. (Salmen et al. 1977b) also conducted an extensive evaluation of geographic information systems available through agencies, universities, and private firms to support the FWS's selection of its information system.

Each of these reviews concluded with recommendations. Ozernoy, Smith, and Sicherman (1981) evaluated the systems and support performance of Intergraph Corp., ESRI, COMARC Design Systems, Inc., Autotrol, and Autometric, Inc.

Calkins and Johnson (1981) evaluated ESRI, Autometric, Intergraph, COMARC, Synercom Technology, Inc. and Earth Satellite Corporation. ESRI and Autometric, Inc., consistently rated high in these evaluations. (Mention here is not to be considered an endorsement of either's systems or their qualifications to provide project-based service to the Cooperative Wildlife Study). ESRI, however, designed the AGR system used by the State of Utah, and Autometric personnel, Dr. Reed in particular, participated in the design of AMS and MOSS, two of the primary software systems in one of FWS's geographic information systems (MOSS has also been incorporated into the BLM's ADS-MOSS system). Salmen and his coworkers (1977b), which included Dr. Reed, selected eleven complete systems and fourteen partial systems from among the 54 for further evaluation. Subsequent analysis and systems architectural work resulted in combinations of parts of these systems into FWS's system.

Alternative 2: Use of PCC Agency or Other Public System

Among the six member agencies, only two can provide GIS/DBMS services at this time, the State of Utah and the Wyoming BLM.

The State of Idaho runs a hydrologic model that incorporates land use data and has used LANDSAT in natural resource evaluations, but it has no plans to obtain a GIS/DBMS. According to Mr. Paul Cunningham (personal communication), Assistant to the Governor, the state cannot afford such a luxury at this time.

The State of Wyoming also lacks a plan to create a state information system. The Game and Fish Department has a five-year plan in which it describes its departmental needs for an information system, but it lacks funding and must await the development of interest and monies in other State agencies and the State as a whole (Crowe, personal communication). The Game and Fish Department plans to use the RAM support software on the University of Wyoming's CDC (Control Data Corporation) Cyber 730/760 computer because the State's IBM 370 computer lacks interactive processing capabilities (Wyoming Game and Fish Department 1979).

The BLM systems are not all at the same operational level in the states of Utah, Idaho, and Wyoming. No system is available in Idaho (Dahl, personal communication) and the Utah State office has not yet acquired its computer and is using Colorado BLM's system (Harne, personal communication). Only the Wyoming state office has an operational system.

The Wyoming BLM system is running in its Cheyenne office. It has all the required equipment, including mid-sized Data General M-600 computer, four digitizing tables, one drum plotter, eight graphics and alphanumeric terminals, and two hardcopy output devices. A staff of 16 operates the system. The staff includes a remote sensing specialist, a remote sensing coordinator, a cartographer, a cartography/drafting/illustration supervisor and 13 full- and part-time technicians (Wyoming BLM, no date). About 60 percent of the workload for system staff is devoted to large planned projects, including assistance in preparing EIS's, EA's, MFP's, etc., and basic GIS resource data

analysis. The remaining work is basic BLM map series production and unscheduled production of special thematic maps and priority field office support (Wyoming BLM, no date).

The system software comes from two sources. The data entry software was developed in-house and is called the Automated Digitizing System (ADS). The analysis and analysis output software is MOSS (Mapping Overlay and Statistical System), developed as part of the software that supports FWS RAM applications. The cartographic output software, called the Cartographic Output System (COS), was likewise developed for and is used by the FWS.

The State of Utah runs its Automated Geographic Reference (AGR) system on a distributed system basis, meaning that jobs can be done at the sites where the products are desired. A large, mainframe Amdahl computer, is stationed in the State Capitol building and is supported with peripheral facilities at ten stations throughout various State agencies. Four have been installed in the Department of Natural Resources. Peripheral equipment includes digitizing tables, interactive graphics terminals, plotters, and smaller Wang computers. The system was just getting underway in 1982 (Dimond, personal communication) and only a small staff of AGR specialists is available to assist users.

Either the State of Utah or the Wyoming BLM could provide GIS services. However, some functional requirements and administrative details would have to be worked out before work could begin.

Functional requirements would include the development of a complete and compatible data base for the study area. Mapping would have to be completed for the desired themes (soils, slope, vegetation, wildlife habitat, etc.). Before mapping was begun, a joint decision would have to be made as to which themes would be used, which would have the highest priority, and what criteria would be used to insure data base uniformity. Uniformity requires consistent scale, level of resolution (minimum mapping area), and classification scheme (although type reclassification could be computerized through simple utility programs). For data to be compatible within the computerized data base, these criteria should be applied uniformly across the three states.

The administrative details include specifying the mechanics and the financial arrangements necessary to get the work done. For example, data on the Wyoming BLM ADS-MOSS system should be in a format compatible with that on the State of Utah's AGR system so that maps from the two states could be merged to form a single uniform base. Data from Idaho would have to be computerized (digitized) and placed on an operational system outside the state. An agency would have to be selected to digitize maps, complete and computerize the data base, and carry out specific applications. Financial support for these operations would have to be arranged because staff at one agency cannot be expected to develop the data base for other agencies, particularly those in other states, without compensation.

Another possibility included under Alternative 2 is to have an outside public agency provide the necessary information system or project services.

The most likely candidate would be the FWS. FWS and WELUT have a pair of operational systems and regularly use them in providing contract services to outside agencies. WELUT in particular could assign well-trained staff that understand computer systems and the needs of the PCC and OIA. WELUT would function in the same way as the outside consultant would in Alternative 1. The information systems operated by WELUT and the Region Six FWS are described in the following section. RAM applications of these systems are also described.

One of the major universities in the three states or in Colorado could also be used to support an information system. Colorado State University supports the Colorado Resource Information System (CRIS) on its CDC Cyber computer and the University of Wyoming's CDC Cyber 170 would be capable of supporting either CRIS or one of the FWS's operational systems (described below). The existence and status of information systems in the other universities is not known. A choice to use one of the university computers and/or information systems would also necessitate many of the same administrative and financial arrangements described above. The PCC agencies would also have to agree on a support staff to operate the system since the universities would not likely provide such services.

INFORMATION SYSTEM APPLICATIONS

Consultant Applications

Most private vendors that install systems at public agencies have had their systems used on natural-resource related issues. Those that do contract work using their own in-house system have done the same. ESRI's work in the area of natural resources will be used to illustrate consultant applications.

The first example is offshore oil development in the Bristol Bay area of Alaska. State and federal agencies in the area are operating under a mandate to develop a comprehensive land use plan for Bristol Bay. The Bay supports one of the largest salmon fisheries in the United States and the surrounding watershed has many other resource values. The purpose of the plan is to protect the natural (vegetation and wildlife), native cultural, and recreational resources of a 50-million-acre area including the Bay itself. ESRI's function was to provide the information necessary to develop the plan. The plan must be completed by the middle of 1983.

In anticipation of the problems, the state and federal agencies had been collecting data and had begun to automate a portion of it. However, no systematized data bank had been developed and the existing information could not be used effectively by the agencies involved. Recognizing the problem, the agencies contracted with ESRI for assistance. The Alaska State Department of Natural Resources, the State Department of Fish and Game, the U.S. Fish and Wildlife Service, and the BLM jointly set the initial scope of work, requested proposals for services, and eventually let the contract to ESRI.

ESRI met with the agencies, helped determine what kinds of data would satisfy agency needs, and indicated how the data would be systematized. In the course of the project, ESRI added integrating data to complete the base, doing all the work on its PRIME computer at Redlands, California. Maps were digitized in polygon form, converted to cell maps, and then multiattribute files were developed to accompany them. The data were formatted so that the tapes delivered to the respective agencies could be used without reformatting. The Department of Natural Resources, the Department of Fish and Game, and the FWS all use Data General computers.

FWS plans to use ESRI's data base, which covers approximately equal fractions of terrestrial and aquatic (marine and freshwater) habitats as the basis for HEP applications to evaluate habitat resources.

The cost of the contract was approximately \$425,000. The work was accomplished in four months.

The second project application was done for the Great River Environmental Action Team (GREAT) of the FWS. In 1976, ESRI was contracted by the FWS to develop a Computerized Inventory and Analysis (CIA) system for the GREAT I Pilot Study Area on the Mississippi River south of Minneapolis, Minnesota. The area included approximately 80 square miles (50,000 acres) in the river corridor. Mapping was done at a scale of 1:9,600 with a resolution of two to three acres. Data were acquired using the Integrated Terrain Unit Method (ITUM) in the form of polygons and the polygons were then converted to cells for later capability and suitability modeling.

The phenomena mapped included: land use, land ownership, power plant intakes and outfalls, aeration structures, water quality monitoring stations, sewage treatment plants, bedrock and surficial geology, landform, slope, soil type, land cover and vegetation, floodplain and floodway areas, river mile address, river and side channel characteristics, shoaling areas, and some data on water velocity.

After producing the automated data bank, ESRI produced a series of over twenty models that were used to identify areas of special biological significance, such as breeding areas for ducks and other waterfowl, prime habitat for upland game, prime habitat for muskrat and beaver, commercial fishing areas, etc. Other models were used to locate bicycle, hiking, and cross-country skiing trails, sites for disposal of dredge spoils, sites for barge fleeting and docking facilities, and for other multiple uses to which the river corridor could be put.

Following the tentative identification of these various areas of multiple use, ESRI and the GREAT I team (personnel from the Fish and Wildlife Service, U.S. Army Corps of Engineers, Departments of Natural Resources and Fish and Game from the states of Minnesota, Wisconsin, and Iowa, etc.) devised ways to resolve potential conflicts that could arise between the types of multiple use under consideration. Through a process of conflict resolution based on compu-

ter maps produced as products of the modeling processes, an acceptable draft plan for the Pilot Study Area was developed.

PCC Agency Applications

State of Utah. Applications of Utah's AGR system are just getting underway. The Division of Oil, Gas, and Mining is using the system to show the locations of abandoned mines with respect to county boundaries to develop the information necessary for federal reclamation funds. This project has just begun (Darling, personal communication).

Several projects have begun or are planned in the Division of Wildlife Resources. Two of the projects are based on life zone maps developed by Dr. James MacMahon at Utah State University and climax or potential vegetation maps developed by several individuals, including Kuchler, Cronquist, and Foster. Dr. MacMahon developed a life zone map of Utah using Holdridge's system (evapotranspiration, precipitation, and other environmental variables). Good correlations exist between these life zones and mammal and herptile distributions.

In the first of these projects, coarse equivalents of MacMahon's life zones have been mapped and digitized at a scale of 1:1,000,000 (Mann, personal communication). These maps will be overlaid with deer herd unit maps to determine the relationships between productive areas and life zones. The goal is to produce a deer management tool. The other project, which has not yet been funded, will be done jointly with the Department of Geology at the University of Utah in Salt Lake City. The vegetation maps produced by Kuchler, Cronquist, and Foster will be digitized and combined to produce a map that can be used in the field. Field biologists will verify and modify the maps as necessary and thereafter they will be used as multi-species and non-game management tools.

The State of Utah has also contracted WELUT to digitize its basic wildlife habitat maps and to computerize the data base for the entire state. At present, only the maps of the eastern third of the state have been digitized (Nish, personal communication).

On other smaller projects, staff is using AGR to illustrate the impacts of recreational and second-home development on deer summer range and to redesign subdivisions to conform better to topography.

Wyoming BLM. The Wyoming BLM has developed its computerized data base by digitizing information on soils, vegetation, range allotment boundaries, fences and other improvements, land ownership, etc., on individual projects in the state. The data base is expanded on a project basis and is currently only partially complete (Keating, personal communication). Most of the data of this sort has been produced using the ADS-MOSS GIS in the State Office at Cheyenne, but additional data has been developed by applying the Interactive Digital Image Manipulation System (IDIMS) produced by NASA for analysis of digital images such as LANDSAT spectral data and of digital

terrain tapes (1:250,000) and digital elevation models (1:24,000). The IDIMS software is available only on the Honeywell H6680 mainframe computer at the BLM's Denver Service Center. In FY 1983, the BLM plans to put all Wyoming IDIMS data products on the Cheyenne Office's Data General computer. Products will include slope maps (from the digital elevation models) and vegetation type maps and suitability maps (based on LANDSAT classification).

As an example of an ongoing project, data is being digitized for the Overland inventory using SVIM (Soil-Vegetation Inventory Method). The area includes 130 7.5-minute U.S.G.S. quadrangles and the BLM is entering data from 910 overlays. These overlays show site writeup areas, soils, allotments, fences and other improvements such as wells and ponds, land net, and surface ownership. Analytical and textual products will include summary tables showing acreages by site writeup area, allotment, and ownership. Soil acreages will be provided by soil type, quadrangle, and allotment. Graphic output will include vegetation and soils maps at scales requested by the Rawlins District Office. Generalized, small-scale planning maps will be available for use in preparing EISs. The data are also to be made available to resource areas for long-term analysis.

On a similar project for the Casper District Office, the Casper Office will request direct access to the SVIM data base. The District Office has a graphics terminal to create that access.

In 1983, the Wyoming BLM will use its ADS-MOSS system to organize data for the Riley Ridge oil and gas development EIS. Information to be digitized includes soils, vegetation, oil and gas facilities, slope, transportation, ownership, wildlife, water resources, and visual resources. The analytical output will be produced to meet the needs of the U.S. Forest Service, the Minerals Management Service, and the BLM.

Other Agency Systems and Applications

Three systems used by agencies outside the PCC warrant attention. The first pair of these are CEREAS, a system developed by the Argonne National Laboratory for use in categorical exclusion review and the associated environmental assessment, and the Colorado Resource Information System (CRIS), a system intended for eventual use in overall resource management throughout the State of Colorado. CRIS has considerably greater overall potential than CEREAS, and has been tested in northwest Colorado in anticipation of accelerated oil shale development there. Both systems will be described and example applications will be provided.

These systems have been used much less than the third system, or pair of systems, developed by the FWS. FWS systems have supported numerous RAM and SAG (Systems Applications Group) applications, both for the FWS and the agencies it advises. Because of their successful applications to industrial development in wildland settings in Wyoming, Montana, Colorado, and Utah, and their prior use by or for PCC and other agencies with jurisdictional authority in and around the Overthrust Belt, they demonstrate the greatest current capa-

bility. Therefore, the computer facilities, the software systems, and the applications themselves will be described and evaluated. Only RAM applications will be reviewed because SAG applications have not been well documented (Gross, personal communication). CRIS, however, uses SAG software and can be considered a SAG application.

CEREAS, Argonne National Laboratory System. CEREAS stands for Categorical Exclusion Review/Environmental Assessment System, a system developed by members of the Natural Resources Section of the Energy and Environmental Systems Division of the Laboratory. No documentation exists on the system other than a brief two-page summary brochure. Therefore, the review cannot be particularly critical. Additional information about the system was obtained through telephone conversations with Dr. Loren Habegger, Natural Resources Section Leader; Dr. James Levenson, Assistant Environmental Scientist; and Ms. Mary Snider, Computer Programmer, all at Argonne National Laboratory (ANL); and with Mr. Carl Pense, Forest Planner; and Mr. Al Reuter, Minerals Forester, on the Bridger-Teton National Forest.

The Minerals Management Service (MMS) uses Categorical Exclusion Review (CER) to accelerate the environmental analysis process required for applications for permits to drill on federal lands. CER streamlines the process, but still meets the requirements of the National Environmental Policy Act. CER is intended to provide the information permitting personnel need to protect resources without placing unnecessary restrictions on drilling for oil and gas. Ultimately, the CER process determines whether or not an Environmental Assessment or an Environmental Impact Statement is necessary.

Nine NEPA criteria are used in the CER process. These nine "exclusion" criteria include those associated with physical, biological, archaeological and historical resources. Information on these and other resources is used to determine whether drilling should be excluded from the area for which the permit has been requested. If the proposed well would fall into one or more of the exclusion areas, the agency can justify refusing the permit.

The system developed by ANL serves as a GIS, storing information gathered from all available sources into a single data base which can be queried with the coordinates (longitude and latitude) of the proposed drill site. Having identified the Overthrust Belt as an area that needed such a system because of the heavy oil and gas exploration and development, ANL staff began to collect information for priority areas identified by MMS environmental scientists. Data for eastern Utah and western Colorado was obtained from the U.S. Forest Service, the BLM, the Raptor Information Center, and the National Register of Historic Places, etc. (Anonymous 1982a). Information was also obtained from environmental impact statements and unpublished reports of research conducted at local universities. Information on each resource was combined into a theme and nine themes were produced, one for each exclusion criterion.

The ANL staff computerized the information to facilitate rapid query. The computer used is the IBM 3033, the large mainframe computer at the laboratory. Additional hardware used in system support are interactive graphics

terminals and an array of plotters and devices for obtaining hard-copy products. These include an HP desk plotter, a 36-inch CALCOMP plotter, and electrostatic plotters.

The system software includes CMS and DISSPLA. CMS is the conversational monitoring system IBM developed for interactive analysis. It is part of the standard IBM virtual operating system. DISSPLA is a graphics and mapping program developed by Integrated Systems Software Company in San Diego, California. ANL uses these two pieces of software because they were already available on the computer when CEREAS was being developed.

To use CEREAS the user answers a short series of questions at an interactive terminal. The user first identifies the plotter or terminal on which he wants the products displayed and then supplies the coordinates of the lease point in latitude and longitude (which is the way the information in the data base has been digitized and stored). Thereafter, the system requests the names of the themes or exclusion criteria which are to be examined or checked in the course of the review and requests the scale and area of the map to be produced, subject to the limitations in terminal screen size and plotter dimensions (36 inches in the case of the CALCOMP plotter).

Using the information supplied and the requested scale, CEREAS provides maps of the themes in a square area centered about the lease point and covering the area desired. For each theme the product is a map of polygons and/or points. These maps can be combined manually for a full constraints analysis but, at present, the system itself cannot overlay and combine maps.

The sole practical application of CEREAS has been a demonstration for Bridger-Teton National Forest. The Bridger-Teton National Forest was in the process of preparing its Forest Plan and had organized data from several internal and external sources. Much of the data was already in map or overlay form suitable for digitizing when the ANL group approached the Bridger-Teton staff with an offer to demonstrate its system.

The Bridger-Teton staff was impressed with the demonstrated speed and potential of the system (Pense, personal communication; Reuter, personal communication), but the system has yet to be transferred because the Forest has no computer on which to run it. As a result, the Forest Service still uses its system of manual overlays. The manual system consists of a plat book of U.S.G.S. quadrangles, each with a set of mylar overlays that show technically unsuitable soils, sensitive wildlife areas, and the information used in the other CER themes. The overlay system is used to review both lease applications and applications for permits to drill (APD).

The Forest Service perceives administrative time savings as one of the principle benefits of a computerized system (Reuter, personal communication). Lease applications are made directly to the BLM. Applications on the Bridger-Teton are made to the Wyoming BLM office in Cheyenne and are sent to the Supervisor's Office (SO) via the Regional Office (RO) in Ogden, Utah. At the SO, the Minerals Forester uses the overlay system to determine what stipula-

tions should be placed on the lease. At the same time, the lease zones into which the lease falls is identified. The application and the stipulations are the stipulations are then sent to the appropriate District Office for approval and returned to the SO. They go back through the RO before reaching the BLM office. This time-consuming process and the associated delays have made a computerized system very attractive. Ideally, the District Office, the SO, and the RO would be linked together on the same computer and the process could be handled interactively.

The ANL suggests that CEREAS could also be used to help conduct the environmental assessment process. The Bridger-Teton National Forest rarely goes through the process without scoping. An interdisciplinary team does the scoping and the subsequent analysis and submits the results to the Minerals Management Service which does the environmental assessment (based on Forest Service recommendations). Although the time frame of the standard case is long (Pense, personal communication), computer assistance would still be valuable.

Colorado Resource Information System (CRIS). The Colorado state legislature has mandated the Department of Natural Resources to enhance and protect natural resources while encouraging energy development as long as it is consistent with realistic conservation principles. The Department's Energy Resource Development Plan Project recognized the need for rapid assessment procedures to meet this mandate and decided to acquire a computerized information system. The Colorado Resource Information System (CRIS) was developed in prototype form for use in northwest Colorado because of the area's strategic significance in national energy production. The system software was designed by the Systems Application Group at WELUT in Fort Collins. Funds came through grants from the Office of the Assistant Secretary for Resource Applications at the U.S. Department of Energy (Hecox 1981).

In resource applications, CRIS is designed to (Weiss and Koulet 1981):

1. improve the quality of information available to state government for use on energy development projects;
2. provide readily interpretable site-specific and generic resource and environmental data to allow comparison of alternative proposed energy tract development;
3. provide for comprehensive, current inventory of site-specific environmental and resource criteria necessary for impact and resource assessment;
4. identify conflicts and possible avenues toward resolution;
5. assist state decision-making; and (eventually)
6. assist natural resource management in the entire state.

The prototype version of CRIS is a complete information system. It was built to demonstrate how a full GIS and DBMS could be used to analyze incremental and cumulative impacts on natural, economic, and social resources.

CRIS design requirements were specified to the Systems Application Group at WELUT. Two criteria were mobile user access and the potential for locating work stations at sites remote from the main computer. The software system has been placed on the CDC Cyber computer at Colorado State University in Fort Collins. Peripheral equipment has been placed at work stations at the Office of the Executive Director of the Department of Natural Resources, Division of Water Resources, Department of Local Affairs, and Division of Wildlife. Access to the main computer from the work stations is achieved over telephone lines.

The CRIS data base includes both spatial and textual data. Spatial data entry, manipulation, and output and display are handled with software routines named MAPDRAW, WINDOW, and CALPLOT (described below). The state data base has been developed on a project-by-project basis, as has been the case with the State of Utah and the Wyoming BLM, and is still incomplete.

CRIS applications to date are concentrated in northwest Colorado where the prototype system was developed. Completed mapping in that area includes land cover (geology, perennial ice and snow, rangeland, endangered and threatened plant locations, topography, etc.), land use (agricultural, archaeology, political boundaries, transportation, urban areas, etc.), land ownership (private and public, the latter by agency and jurisdiction), fish and wildlife (game, non-game, endangered and threatened), and energy (reserves, ownership, production, conversion, and transmission) (Hecox 1981). Koulet and Nelson (1981) prepared a paper illustrating the use of the system on multi-mineral lease tracts in northwest Colorado. The following description is based on that paper.

A wealth of mineral resources, including commercially valuable nahcolite, dawsonite, and oil shale in northwest Colorado attracted mining companies and stimulated the Department of the Interior's Prototype Oil Shale Leasing Program. Thirteen tracts considered for leasing under this Prototype Program, six additional tracts nominated under the Department of Interior's aborted In-situ Leasing Program, and a single multi-mineral tract owned by the Multi Mineral Corporation were evaluated and ranked using cumulative hierarchical ranking procedures. The ranking procedure accounted for potential mineral and economic values and the state of surface natural and cultural resources. Jointly, these parameters determine each tract's minability. The results are used to decide which tracts should be leased.

The criteria used to rate each tract were derived from the data available in CRIS. For this particular demonstration, mineral resource or energy data, wildlife habitat data, fishing stream data, irrigation potential data, and archaeological data were used.

Each tract was rated in terms of the thickness, richness, and yield of nahcolite-, dawsonite-, and oil-shale-bearing formations. Three classes were possible for each criterion. For example, a zone of nahcolite 800-1,000 feet thick would be assigned to thickness class A, indicating highest value. A 300-foot-thick zone would be rated poorly, and be placed into thickness

class C. If the formation containing it contains 15-20 percent by weight of nahcolite, it would be assigned to richness class A, again indicating highest value. Similar procedures were used for yield. Values for thickness, richness and yield were then combined to produce a composite mineral resource value ranking.

CRIS habitat type maps were used to determine the values of the habitat in each tract for black bear, bobcat, blue grouse, elk (calving area, winter range, migration route), bighorn sheep, prairie dogs, and bald and golden eagles. Each tract was evaluated in terms of cumulative habitat value for the full set of species considered in the analysis. Four ratings were possible: high, medium-high, medium, and low wildlife value.

The study area contained class two, three and four fishing streams. Class-one streams, those having the highest fisheries values, were not present.

Tracts with more high-value wildlife habitat and highly rated streams received higher rankings than tracts with fewer acres and fewer highly rated streams. Therefore, the tracts with the highest fish and wildlife values were considered least suitable for multi-mineral development.

The same type of procedure was used for irrigation potential and cultural and archaeological resources. Tracts with fewer acres that are potentially suitable for irrigation and agricultural production and fewer acres that are archaeologically significant were considered more suitable for multi-mineral development and received higher rankings.

Tables 1-4 and 1-5, taken from Koulet and Nelson's (1981) demonstration paper, show how each tract was ranked according to its suitability for dawsonite development and potential conflict with wildlife resources.

The results in each of these and the other tables were obtained by converting mapped data from polygon to cell form. Maps were digitized as polygon mosaics and then a software program (CELLGEN) was used to convert polygons to a grid of cells. Figure 1-2 shows how several "layers" of information on nongame species, game species and threatened and endangered species could be treated to arrive at a cumulative or composite wildlife habitat value. Each cell map incorporates the weights used in making the ratings. The non-game species ranges, critical winter range, and nesting areas for threatened and endangered species receive the highest weights and ratings. The composite cell map shows the relative importance of each cell. Cells with the highest relative value for wildlife and which are, therefore, least suitable for multi-mineral development, contain the highest numbers.

Table 1-6 shows the relative suitability of all 20 tracts for multi-mineral development. As the table shows, the tracts with the highest rankings do not necessarily possess the highest relative suitability rank. In spite of relatively low mineral values, tracts C-1 and FEDIST5 are most suitable for development because they have few environmental conflicts.

TABLE 1-4

**RELATIVE SUITABILITY FOR DAWSONITE DEVELOPMENT,
DETERMINED USING COLORADO RESOURCE INFORMATION SYSTEM¹**

Tract	Dawsonite Class A (acres)	Dawsonite Class B (acres)	Dawsonite Class C (acres)	Relative Ranking
MULTI-MINERAL	9,728	410	0	1
FEDIST5	5,760	0	0	2
C-11	5,120	0	0	3
FEDIST1	4,762	307	0	4
C-6	2,662	2,406	0	5
FEDIST6	2,406	128	0	6
C-1	1,792	896	0	7
C-10	410	4,608	0	8
FEDIST4+6	410	2,099	0	9
C-16	0	3,110	2,592	10
C-b	0	2,458	2,611	11
C-a	0	2,048	2,970	12
C-3	0	2,202	461	13
FEDIST4	0	1,638	794	14
FEDIST2	0	0	5,120	15
C-15	0	0	358	16
C-2	0	0	0	17
C-9	0	0	0	17
C-12	0	0	0	17
C-14	0	0	0	17

¹Source: Koulet, K.G. and P.R. Nelson. 1981. An evaluation of potential multi-mineral lease tracts in the Piceance Basin, Colorado: a demonstration of the Colorado Resource Information System using a cumulative hierarchies ranking methodology for resource and environmental assessment. Colorado Energy and Natural Resource Management Program, Colorado Department of Natural Resources.

TABLE 1-5

RANKINGS BASED ON WILDLIFE CONFLICTS AND IMPACTS,
DETERMINED USING COLORADO RESOURCE INFORMATION SYSTEM¹

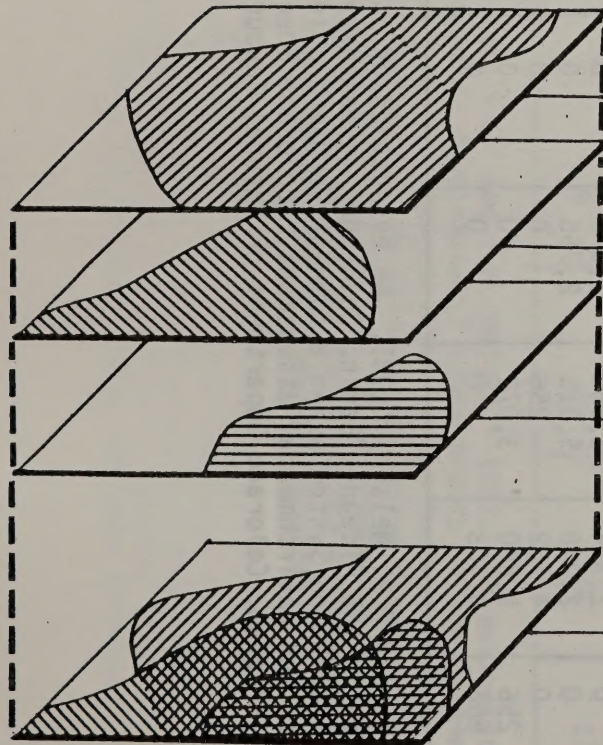
Tract	High (acres)	Medium-High (acres)	Medium (acres)	Medium-Low (acres)	Low (acres)	Threatened & Endangered Species (acres)	Relative Ranking
C-16	0	0	173	5,530	0	0	1
C-3	0	0	307	4,147	563	0	2
FEDIST4	0	0	410	2,125	0	0	3
C-a	0	0	410	4,557	51	0	4
FEDIST6	0	0	486	2,048	0	0	5
FEDIST5	0	0	922	4,781	0	0	6
FEDIST4+6	0	0	1,229	1,306	0	0	7
C-1	0	0	1,613	2,822	0	0	8
C-10	0	0	2,099	2,970	0	0	9
C-6	0	102	1,126	3,840	0	0	10
FEDIST2	0	102	4,966	0	0	0	11
C-b	0	410	4,659	0	0	102	12
C-12	0	205	2,099	2,765	0	410	13
C-2	0	653	691	2,534	0	346	13
C-11	0	1,299	3,840	0	0	154	14
FEDIST1	0	2,304	1,638	1,075	0	0	14
MULTI-MINERAL	0	2,048	5,325	2,765	0	0	15
C-15	0	4,762	256	0	0	3,379	16
C-9	256	1,690	3,072	0	0	5,120	17
C-14	666	4,403	0	0	0	5,120	18

¹Source: Koulet, K.G. and P.R. Nelson. 1981. An evaluation of potential multi-mineral lease tracts in the Piceance Basin, Colorado: a demonstration of the Colorado Resource Information System using a cumulative hierarchies ranking methodology for resource and environmental assessment. Colorado Energy and Natural Resource Management Program, Colorado Department of Natural Resources.

FIGURE 1-2

COMPOSITE LAYER MAPPING

Polygon Maps



The Composite Polygon Map shows combined ranges by overlapping patterns.

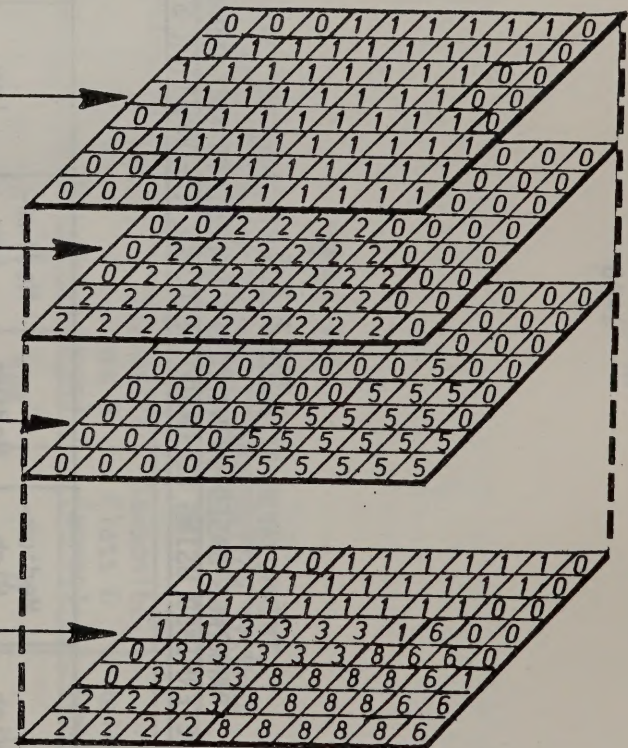
NON-GAME SPECIES
(overall range)

GAME SPECIES
(critical winter range)

THREATENED &
ENDANGERED
SPECIES
(nesting area)

COMPOSITE MAPS

Cell Maps



The Composite Weighted Cell Map shows relative wildlife suitability in each cell. (High numbers indicate low suitability for multi-mineral development.)

TABLE 1-6

RELATIVE SUITABILITY FOR MULTI-MINERAL DEVELOPMENT AMONG ALL ORIGINALLY PROPOSED OIL SHALE TRACTS,
AND FEDERAL IN-SITU TRACTS BASED ON RANKED CRITERIA¹

Criteria Type Tracts	Sum of Minerals Rankings	Wild- life Rank	Archaeology Rank	Irrigation Potential Rank	Fishing Stream Rank	Sum of all Ranks	Relative Suitability Rank
C-a	40	4	10	4	12	70	15
C-b	27	12	3	4	11	57	10
C-1	22	8	1	3	1	35	1
C-2	47	13	1	2	1	64	12
C-3	41	2	1	6	1	51	7
C-6	13	10	1	9	10	43	4
C-9	38	17	1	4	9	69	14
C-10	24	9	8	4	7	52	8
C-11	13	14	9	4	5	45	5
C-12	47	13	2	8	3	73	16
C-14	38	18	1	4	14	75	17
C-15	39	16	1	4	13	73	16
C-16	24	1	1	5	8	39	3
FEDIST1	9	14	8	10	9	50	6
FEDEST2	37	11	5	7	6	66	13
FEDIST4+6	28	7	6	1	15	57	10
FEDIST4	39	3	4	1	16	63	11
FEDIST5	10	6	11	5	4	36	2
FEDIST6	25	5	7	1	17	55	9
MULTI-MINERAL	5	15	12	11	2	45	5

Source: Koulet, K.G. and P.R. Nelson. 1981. An evaluation of potential multi-mineral lease tracts in the Piceance Basin, Colorado: a demonstration of the Colorado Resource Information System using a cumulative hierarchies ranking methodology for resource and environmental assessment. Issue paper 13. Colorado Energy and Natural Resource Management Program, Colorado Department of Natural Resources.

CRIS offers savings in time and money in performing such analyses. Little is done by the computer that cannot be done by hand, but the advantages of automated processes continue to accrue once the required data have been entered and are ready for manipulation and statistical treatment. Thereafter, analyses are relatively inexpensive and rapid.

FWS Systems and Applications

Computer Facilities and GIS/DBMS Systems. FWS currently uses many computer facilities, public and private, in-house and at other governmental agencies. For this study, the most important are the facilities at WELUT in Fort Collins and at the National Oceanic and Atmospheric Administration (NOAA) at Boulder. The computer at WELUT is a Data General mini-computer. The computer at NOAA is a large Control Data Corporation Cyber mainframe computer. Each supports a different information system and receives somewhat different use.

The system on the Data General computer at WELUT includes a large number of software programs, among them several utility programs designed to accomplish specific tasks. The three primary software packages are AMS, MOSS, and COS. AMS, the Analytic Mapping System, is used to digitize maps and create geographic data bases. MOSS (the Map Overlay and Statistical System) is used to manipulate, combine and display maps and to summarize, analyze and display map data. COS (Cartographic Output System) is used to generate graphic products of cartographic quality. This system of software will be referred to as the "RAM system" because WELUT has applied no other name to it. This name should be considered no more than a shorthand attempt to identify that particular software combination. It does not imply that the RAM Group, the WELUT group responsible for developing rapid assessment methods, uses no other information system. The RAM group uses whatever software best serves the purpose of a project, including SAGIS (Systems Application Group Information System) described below.

MOSS was originally developed for the Cyber but around 1977 some feeling developed in the FWS that the mini-computer offered greater future potential and the Region Six version of MOSS developed for the Cyber was left unimproved when MOSS was converted for use on the smaller Data General computers (Hamill, personal communication). It still contains many of the programming errors it had five years ago, is in poor condition, and receives essentially no use by Region Six FWS personnel. Elsewhere, FWS has improved its Cyber versions of MOSS.

Although the movement toward smaller computers never occurred in the FWS as it has in the BLM (Keating, personal communication; Strand, personal communication), both the BLM and WELUT have continued to improve the versions of MOSS they use on the Data General computers. To facilitate data exchange and the mutual benefit of their independent efforts, the two agencies reached a cooperative agreement to incorporate each's improvements into a master version of MOSS. The jointly improved version will be flexible enough to accommodate mutually exclusive agency requirements, but be similar enough to make the

exchange of information efficient and cost-effective (Asherin, personal communication; Strand, personal communication).

The system on the Cyber computer at the NOAA facility is the Systems Application Group Information System (SAGIS), so named because it was developed by members of the Systems Applications Group at WELUT. SAGIS has three principal software components, each with its counterpart in the RAM system. MAPDRAW and QUICKDRAW are the data entry programs and serve as the equivalents of AMS. WINDOW is the data manipulation, etc., package used instead of MOSS. For output products CALPLOT replaces COS.

The RAM and SAGIS systems were designed for different purposes and had quite different design histories. The RAM system was developed following a five-month assessment (Salmen et al. 1977a) of the needs of staff at the Denver Region Six Offices, the Billings Area Office in Region Six, and the Special Projects Groups of the Office of Biological Services, particularly at WELUT. Since the array of needs expressed were very broad, the RAM system was designed from the start to possess the broad capabilities that would suit it to a wide range of applications. Users were supplied with a general-purpose system and picked and chose from among the several tools available, those tailored to individual project needs.

The RAM system did not, however, remain stagnant in its original state. WELUT staff improves and extends RAM software, integrating other routines and programs (Yale's MAP software, for example) as necessary to promote more efficient and cost-effective use of an increasingly powerful system (Asherin, personal communication).

SAGIS developed in an entirely different way. Work on SAGIS began at Colorado State University under Dr. Jack Gross, but has continued with his move to WELUT. In spite of its evolution to meet the needs of regional clients, the system is not a general-purpose system (Gross, personal communication). Improvements were made on a project-by-project basis whenever the Systems Applications Group faced new problems and requirements.

Both systems are used by FWS regional and field-office personnel. The RAM system is used extensively by WELUT, the National Wetlands Inventory Team, the National Coastal Ecosystems Team, and the Alaska Regional Office. In Region Six, the system was used to support energy operations in Utah, Colorado, Montana, Wyoming, and North Dakota. In terms of income, most of the support for RAM Group applications has come from other agencies (Asherin, personal communication). SAGIS has been used in setting up the Great Lakes Information Management System and is now being used by Region Two and Region Five. It has been used in Colorado, Wyoming, and Montana. Compared with the RAM system, it has received greater use by Region Six FWS staff (Hamill, personal communication; Bowen, personal communication; Johnson, personal communication) and the Systems Application Group has been considered a valuable in-house system developer (Hamill, personal communication).

The two systems should be considered complementary rather than competitive counterparts (Asherin, personal communication). In Region Six, for example, AMS is used for large production jobs and to prepare complex land cover maps. MAPDRAW and QUICKDRAW are used for smaller ad hoc digitizing jobs and for editing. WINDOW is used for map data analysis and CALPLOT is used to produce map products. Nevertheless, certain comparisons have been made that indicate their relative strengths and weaknesses. They are presented in summary form in Table 1-7.

The two systems use essentially the same kind of data. However, the data are formatted differently. Data records are written and entered into a computer according to a particular format so that the computer can read them. Each system "understands" data in certain formats and not in others. Formatting conversions are sometimes necessary if a user desires to employ data formatted for one computer in an analysis using another. Conversions are made through interface modules, programs that function as translators. Programmers can create them with little trouble but the actual computer conversions are cumbersome and costly. Programs to reformat WAMS and MOSS data have been created so that data entered on the Data General can be analyzed on the Cyber using WINDOW. According to Strand (personal communication), the original version of MOSS developed for the Cyber could read data digitized using QUICKDRAW and MAPDRAW, but the version is plagued with numerous errors and a conversion would not be desirable. The Data General version of MOSS, however, cannot read SAGIS data.

Another important software system is MANAGE. MANAGE is a general-purpose piece of software designed for data base management. MANAGE is used to enter non-geographic data into the computer, including textual and tabular information but could also be used to complement MOSS. MOSS allows over 200 attributes to be stored for a cell or polygon but does not permit Boolean searching using several attributes (Strand, personal communication). MANAGE would permit such sophisticated searching. The necessary link between MANAGE and MOSS has not been developed, but the first version of the interface between WINDOW and MANAGE has been developed, is operational, and further design and development are in progress (Anonymous 1982; Strand, personal communication).

RAM Applications

RAM is the acronym for "Rapid Assessment Methodology". RAM is a collection of computer-based tools, computerized data bases and models created to solve resource assessment and management problems (Hamill 1979). RAM tools were originally developed to provide the FWS the tools it needed to assist the BLM administer leasing as part of the Department of Interior's Coal Management Program. As an advisor to the BLM, the FWS is required to supply information on fish and wildlife resources. Computer-based tools were considered to provide the FWS the capacity to respond rapidly to BLM needs.

RAM's technical foundations include more than computerized information systems. Other tools complete the RAM kit. LANDSAT imagery, aerial photography, photointerpretation and map-making from aerial photography also

TABLE 1-7

RAM-SAGIS SYSTEM COMPARISON¹

FACTOR	QUICKDRAW MAPDRAW-WINDOW-CALPLOT	WAMS-MOSS-COS
Operating Philosophy	Designed on a piecemeal basis to provide analysis capabilities in direct response to specific project needs (designed from the top down).	Design to provide an array of general map analysis capabilities from which the user may choose to address a problem (designed from the bottom up).
Operational Status	Extensively applied in an operational setting to a wide variety of problems. Very reliable and stable.	Portions are not reliable or operationally tested.
User Clientele	Requires a fairly sophisticated, practiced user for efficient operation. More suited for broad synthesis than detailed analysis.	Designed to be operated by a user with little or no technical background (although COS is difficult to use). More applicable to site-specific analysis.
Input Limitations	Limitations as to the complexity of the data that can be entered.	No limits on the amount of data that can be entered or on its complexity.
Output Quality	Efficient analytical capability rather than the capacity to produce high-quality displays and summaries. Moderate cartographic quality, suitable for office and field use.	High-quality and concise displays and tabular summaries. Cartographic quality excellent and suitable for use in formal presentations and publications.

TABLE 1-7. CONTINUED.

FACTOR	QUICKDRAW MAPDRAW- WINDOW-CALPLOT	WAMS-MOSS-COS
Operating Cost Response Time	Cost- and time-efficient.	Some capabilities are relatively costly and require long waits for execution.
Quality of Documentation	Fair to good.	Good to excellent.
Hardware (computer)	Large Cyber mainframe which provides virtually unlimited data storage and user access from remote locations.	Data General mini computer (DG Eclipse C-350 and MV 8000) with limited storage and remote user access.
Portability	Restricted to Cyber.	Portable but conversion from Data General would be costly.
Data Type	Cells for analysis; cells and polygon for display	Polygons for analysis and display; cell-based capability under current development.

¹Sources: Anonymous 1982b. MOSS-COS/WINDOW-CALPLOT comparison. USDI Fish and Wildl. Serv., Region 6. Unpublished. June, 1980; revised October, 1982.

Personal communication, Hamill, Bowen; Gross, Johnson, 1982.

support RAM applications. However, computer technology is the fundamental technical underpinning and philosophical cornerstone of RAM; few rapid assessments are made without using RAM or SAGIS systems and their associated utility programs.

Most RAM applications use WAMS and/or MAPDRAW and QUICKDRAW, MOSS and WINDOW, and COS and CALPLOT to create and analyze maps. MOSS and WINDOW, the software analysis packages, enable the user to conduct analyses of maps and mapped information that would be so time-consuming and costly if done manually that they would normally be economically infeasible. Among the general kinds of analyses and manipulations possible with either the RAM or SAGIS system are the following:

1. combination of maps - once an area has been mapped, several themes (soils, slope, vegetation, wildlife habitat, road network, oil and gas facility locations, etc.) can be combined. Maps can be produced showing whatever combinations are desired, i.e., all pinyon-juniper vegetation on south-facing slopes over 30 percent, all bald eagle nests within 500 yards of proposed roadways and industrial facilities, all the critical elk winter range within potential oil shale lease tracts, etc.
2. searches for particular types of resource conditions - all elk winter range areas that are greater than ten acres and smaller than 100 acres could be calculated using one of several spatial "retrieval" functions. Other possible analyses involving size and distance criteria include calculation (and storage as a new map) of for example, the common edges between water bodies and proposed strip mine leases, identification and storage as a new map of all the sage brush types that abut douglas-fir-aspen types, etc.
3. calculations of the distance between two locations - as between a known sage grouse strutting ground and a location at which a request for drilling is being made in an application for a permit to drill.
4. summaries of map information in the form of tabular reports - perimeter data can be given for any polygon-based map information, acreage can be calculated for any number of types represented on the map (including the areas of buffer zones the user can have the computer place around streams or point resources such as nests). Frequency tables and histograms of desired information can also be quickly generated.
5. ranking of alternative development areas and scenarios - the cumulative hierarchical ranking method is but one of five ranking methods developed by the RAM and Systems Applications Groups at WELUT.

Computer-based methods allow analyses to be done that would otherwise not be possible, particularly in situations where time is limited. The same holds for the production of maps. Combinations of maps can be displayed on inter-

active terminals for inspection and data summaries of the kinds listed above can be requested. If the results suit the need of the user hard-copy versions suitable either for office use or for public presentations can be produced. The elimination of extensive drafting time alone can make computer mapping products feasible and attractive where manual versions would be economically impossible.

RAM applications have been undertaken by the WELUT RAM Group in support of Region Six FWS Energy Operations and for the Forest Service and the BLM. In 1982, the RAM Group provided the following services to Region Six (examples): surface cover mapping in the Ft. Union Known Recoverable Coal Resource Area in Montana, riparian habitat mapping along 192 miles of Missouri River floodplain using four sets of sequential aerial photography covering the period from 1938 to 1982, and surface cover and land use mapping for nine counties in eastern Utah and five counties in northwestern Colorado from 1:250,000-scale LANDSAT color composite images.

For the Colorado State Office of the BLM, the RAM Group computerized a multiple-resource data base (60 themes) covering 1820 square miles. (The extensive digitizing was done at WELUT by contracted labor from Technicolor Government Services and Colorado State University). These maps became the spatial data base for BLM planning and oil shale leasing. For the Forest Pest Management Group of the Forest Service, the RAM Group developed another multiple-resource spatial data base covering 550 square miles of Pike National Forest, Colorado, and then developed interfaces with forest pest economics models that now permit joint use of the spatial data and the models in forest planning.

Four detailed examples will illustrate RAM applications by WELUT and other agencies. These include applications by: 1) WELUT for the Platte River Trust to preserve and manage critical habitat for the sandhill and whooping crane, 2) the National Coastal Ecosystems Team to analyze trends and the effects of oil spills along the Gulf Coast, 3) the Bureau of Indian Affairs (BIA) to manage forests and agricultural areas on Indian reservations, and 4) the BLM in the White River Resource Area in Colorado.

The NCET, BIA, and BLM applications will be described here. WELUT's Platte River application is deferred to the Combinations of Procedures section because it involves the joint use of GIS technology and computerized habitat evaluation procedures.

National Coastal Ecosystems Team RAM Applications. The NCET is responsible for developing and synthesizing ecological information on coastal areas of the United States. Masses of textual information and numerous maps have been prepared or obtained. As part of its responsibility, the NCET is working to organize this data for rapid availability to federal, state, and local agencies, environmental groups, and private industry. Its rapid-service requirements made computer-based geographic information and data base management systems necessary. Initially, NCET, which is located in Slidell, Louisiana, installed MANAGE on a Univac 1100 computer and used it used to

statistically analyze tabular data prepared by manually planimetering numerous maps.

Eventually, NCET decided to upgrade its capacity and installed the RAM system used by WELUT (Ader, personal communication) on a Data General Eclipse minicomputer at NCET. The system is now being used in the habitat trend analyses and to evaluate the impacts of oil spills in the coastal zone. (Ader and Stayner 1981).

Coastal habitat trend analyses are underway in every state bordering the Gulf of Mexico. One of the most important projects was undertaken in the active delta region of the Mississippi River. The U.S. Army Corps of Engineers had been mandated to dredge and increase the depth of the Mississippi River channel. The NCET suggested that the dredged material be placed in the delta to replace disappearing wetland habitat. To identify potential disposal locations, NCET mapped four habitat types (marsh, forested wetland, upland, and spoil) on aerial photographs taken in 1956 and 1978. These photo-based maps were then digitized and subject to computerized statistical analysis to determine where losses had occurred and where replacements would be most effective.

Although MOSS's statistical analysis capabilities were beneficial (in quickly obtaining acreage estimates, etc.) on this project, the greatest gain came from the output products created using COS. High-quality maps used in the Louisiana Senate and House Committee on Natural Resources to portray the changes were responsible for an allocation of \$35 million to various state agencies to control wetland loss. According to Ader and Stayner (1981) such high-quality graphics have had a significant influence on State and Federal decisions regarding coastal resources.

NCET has also used its information system to determine how best to respond to potential environmental hazards created by Louisiana Offshore Oil Port (LOOP) operations. NCET recently used MOSS to set protection priorities for on-shore and near-shore areas off the Louisiana coast. Based on its physical proximity and identified resource values, each area of the quadrangle was classified according to its vulnerability. Vulnerability was based on eight resource variables, including: the presence and condition of wetland habitat, oyster leases, recreational beaches, historical sites, endangered species, marinas, water intakes, and bird rookeries.

These features and resources were initially digitized from photo-based map overlays in the form of polygons and points. The polygons were converted to cell maps to conduct the vulnerability analyses because the computer operations are simplified using cells. Each cell contained one or more of the above eight resources, each of which had a certain vulnerability to oil spills. Total or combined vulnerability was obtained by arithmetically compositing the eight cell maps. The total vulnerability ratings were then used as the attributes for a new map showing vulnerability only.

This vulnerability map and other products still in preparation are being used to manage oil spill cleanup activities and to insure optimal deployment of cleanup forces. This map indicates where cleanup activities should first be concentrated. The vulnerability maps have been cartographically reproduced using COS onto opaque stable-base mylar for use as overlays on topographic quadrangles.

BIA RAM Applications. The Sacramento Area Office of the Bureau of Indian Affairs (BIA) is using WAMS, MOSS, and COS in RAM applications to assist in the management of reservations. Currently, the BIA is connected by telephone to the Data General 350 at WELUT and conducts its analyses remotely at a work station in the Sacramento office. The BIA and WELUT have an inter-agency agreement to cover the costs of digitizing (which is being done at WELUT by Technicolor Government Services), plotter time, and administration.

Previous applications have been for the 88,000-acre Hoopa Indian Reservation in northwest California. All USGS quadrangle information, forest soils, land ownership, timber harvest areas (type and year of harvest have been entered as polygon attributes), and timber types have been digitized. Entry of digital elevation model data will soon permit slope and aspect mapping and three-dimensional modeling will be possible (Wright, personal communication).

The computerized data base is being used to develop five-year timber harvest plans for the reservation and to evaluate the effects of certain resource protection measures on the allowable cut. As part of these evaluations, the BIA is using MOSS to determine how stream buffer zones of different widths affect the volume of harvestable timber. With MOSS, the user can have the computer draw a buffer zone of any specified width about points or linear features. BIA staff produced 150-foot-wide buffer strips about the network of streams present, overlayed them on timber type maps, and obtained statistical summaries of the acreage of each timber type within the buffer zones. Forest inventory data (average volume per acre for each forest type) were then used to obtain the total timber volume in the 150-foot-wide buffer zones. The result indicates how the allowable cut would be reduced if no harvesting was permitted in streamside buffer zones.

The advantage of using a computer to conduct these analyses is speed. Previously, the BIA had allocated six months to do the calculations when the work was done manually; less than one week was necessary using MOSS (Wright, personal communication). The savings in time were particularly valuable because it allowed the BIA to consider the effects of several alternative buffer zone widths. The considerable savings in time also allowed the BIA to expand the evaluation to determine how additional restrictive streamside protection requirements on erodible soils in the buffer zone would further reduce harvestable timber volumes. This expanded evaluation would not have been possible without the speed and power of MOSS and its mapping capabilities.

The speed and power of computer overlaying and statistical summary capacities have also been used in regeneration evaluations. As part of the

continuous forest inventory process, the BIA makes regeneration surveys in previously harvested cutblocks. Although the BIA foresters assumed that regeneration success varied with soil type, no quantitative information was available to confirm the assumption. By overlaying harvest blocks and soil types, obtaining acreages of each soil type, and then using locally computerized regeneration data, the BIA developed strong correlations between soil type and regeneration success through very rapid queries. Manually, the analysis would have taken several days; assisted by computer, the analysis took less than an hour.

The BIA also uses the system on the Yakima Reservation in Washington and plans to use the RAM system on other reservations such as the Jicarilla in northern New Mexico in the future. On the Yakima Reservation the system is being used to identify and map irrigable lands and to assist in the design of irrigation systems.

BLM RAM Applications. The BLM has its own ADS-MOSS system which, depending on the state, is currently either operational, semi-operational, or non-operational in each state office. The system is now operational in Colorado but WELUT's RAM system is being used in the White River Resource Area because a system was necessary before the state system was operational and the RAM system was the best-tested system available (Montgomery, personal communication). The White River application is unusual because in other states the BLM does not plan to provide for access to its state systems at the Resource Area level.

The RAM system is being used to assist in the development of an oil shale leasing program for the Piceance Basin, which is in the White River Resource Area. It will also be used to aid comprehensive analysis required to develop a Resource Management Plan (RMP) (Hunter and Montgomery, no date). The utility of the geographic information system, the associated data bases, and the rapid methods of using both together appears to Sam Montgomery, Community Planner with the Colorado State BLM Office (Montgomery, personal communication), to apply across the full process leading to the RMP, from issue identification to monitoring and evaluation of the effects of the preferred alternative. The strongest capabilities, however, reside in the analysis of multiple alternatives. Manual data analysis for each alternative is so time-consuming that, under normal time and budget constraints, only a few alternatives can be considered. Computer assistance enables the BLM to consider many more alternatives, some of which are quite similar and would definitely go unconsidered if rapid computer analysis methods were not available (Montgomery, personal communication).

SUMMARY EVALUATION OF GIS APPLICATIONS

Three alternative mechanisms exist for applying computerized GIS technology to the Overthrust Belt: use of a GIS already in operation at one of the PCC agencies, either the State of Utah or the Wyoming BLM; contract applications by a private GIS operator selected by the PCC; use of a GIS operated by another public agency such as FWS or its Western Energy and Land Use Team

(WELUT). A choice between these three alternatives within the context of the OIA's Cooperative Wildlife Program would have to follow a prior decision on the allocation of OIA funds to a range of high-priority activities. These would likely include efforts to improve the existing wildlife and habitat data base in the three-state study area and to increase the understanding of existing development impacts and associated mitigation strategies.

Table 1-8 summarizes in tabular form an evaluation and comparison of these three GIS implementation alternatives. The Rapid Assessment Methods developed by WELUT rely heavily upon the fundamental computer capabilities available with WAMS, MOSS, and COS or other supporting software (Asherin, personal communication). Other computerized information systems with similar capabilities can be used to make the same type of rapid assessments of wildlife resources and the potential impacts of development. Utah's AGR system and the Wyoming BLM's ADS-MOSS system both provide the kind of support RAM applications require. Rapid assessments and applications of RAM tools are not peculiar to WELUT, the FWS, or their information systems. Any agency or organization possessing computer capabilities can make RAM applications with the proper software.

The primary difference between GIS applications by the WELUT RAM Group and similar applications by the other PCC agencies is probably the speed and efficiency with which they are accomplished. WELUT has a staff of practiced users and more project experience. Private firms such as COMARC, ESRI, Autometric, Inc., etc. also have practiced staffs that use their own systems rapidly but that capacity has come from experience and familiarity with both the hardware and software. Wyoming's BLM staff appears capable of making RAM-like applications using its ADS-MOSS system, but Utah's AGR staff has less than two years' experience with its system (Darling, personal communication) and Division of Wildlife Resources personnel are even less experienced.

Although RAM applications depend on the capabilities of the combined hardware and software and on the user's abilities, they ultimately require a costly initial investment in computerizing the necessary data. Data entry is the most time-consuming and costly task of bringing a computerized information system into an operational state. The potential user must know how heavily the system will be used and how frequently RAM applications will be made before a decision is made to install a system. However attractive RAM may appear, the wisdom of making the expensive but necessary initial investment will depend upon the number of eventual applications. If frequent applications are likely, the initial costs of computerizing maps and textual information can be recovered in the form of repeated savings in time and money throughout future use. Under such circumstances, the acquisition of the system (or system services) may be economical. GIS applications require an advance commitment. Once the data base has been computerized, failure to use the GIS would be very costly.

One practical and valuable advantage of computerizing maps and textual information is the opportunity for users to access the data base from remote

TABLE 1-8
SUMMARY EVALUATION AND COMPARISON OF ALTERNATIVE GIS APPLICATIONS

Evaluation Criteria	Alternative		
	PCC Agency	FWS or WELUT	Outside Contractor
Utility in meeting PCC objectives:			
Identify environmentally sensitive areas	High	Moderate to High	Moderate
Assess development impacts	High	Moderate to High	Moderate
Assist in development of mitigation programs	High	Moderate to High	Moderate
Utility in overall planning process:			
Collaborative analysis	Moderate	Moderate to Low	Moderate to Low
Description and assessment of wildlife resources	High	Moderate to High	Moderate to High
Evaluation of development and management alternatives	High	Moderate to High	Moderate to High
Selection of preferred development and management alternatives	High	Moderate to High	Moderate to High
Project monitoring	Unknown	Unknown	Unknown
Reevaluation of development and management alternatives	Unknown	Unknown	Unknown
Costs of application	Low to Moderate	Moderate	Moderate
Speed and efficiency	Moderate	High	High
Administrative difficulties	Low to	Low	Low

locations. However, given the status of peripheral facilities (interactive terminals, thermal printers, plotting devices, etc.) in the Idaho agencies and the Wyoming Game and Fish Department, full PCC remote access to a computerized information system would not be possible in the near future.

In terms of utility in meeting the three primary PCC objectives, the three alternatives are functionally equivalent in that any properly operated RAM possesses the capacity to identify environmentally sensitive areas, assess impacts, and assist as a tool in developing mitigation strategies. The difference in the rankings, which is also considered in the table under administrative difficulties, is due to the applications being conducted out-of-house in the case of FWS, WELUT, or an outside consultant. PCC agency familiarity with the basic data and the resources in the study area could potentially offer an advantage. Administratively, communications between PCC biologists, etc. and WELUT or consultant GIS operators would be made more complicated by their physical separation.

The planning process outlined in the introduction to this chapter can also provide a basis for evaluating applications and comparing alternatives. RAM applications could be useful at all six steps as outlined, but their greatest potential utility would be at steps two through four. Comparatively, the three alternatives are functionally similar but Table 1-8 indicates that some differences are perceived between them.

Step one in the process, collaborative analysis, includes public involvement, issue identification, problem definition, and conflict resolution. Computerized GIS applications are not typically intended to obtain public input or resolve conflicts. Use of GIS, however, can facilitate the development of issues. For example, the map compositing and data summary capabilities can allow agency staff to develop preliminary information and anticipate the kind of issues that might arise in response to particular alternatives for industrial development and/or management. Maps and statistical summaries prepared in advance of public participation workshops could enable agency personnel to portray potential resource conflicts and to stimulate discussion among the attendants. The rapid analysis capabilities could facilitate the development of questions for use in Delphi applications, seed the generation of item lists in NGT meetings, and assist in the development of simulation models used in AEAM workshops. The applications for use in AEAM workshops could be particularly valuable because of the limited time facilitators have for developing the models. WELUT staff (Andrews, personal communication) indicates that computer information system capabilities would have improved the Jackson Hole AEAM application and could, in general, improve the level of spatial resolution possible and the power and value of the computer models. Generally, however, the utility would be moderate to low, the difference between alternatives being one of lesser familiarity with resource issues outside of PCC agencies.

Step two includes inventory design and data collection, data organization and synthesis, and data storage as well as subsequent description, assessment, and analysis of wildlife and wildlife-related resources. Computer-assisted

acreage summaries can be made in seconds, thereby reducing survey design time and permitting a larger sample under budgetary constraints. GIS applications, therefore, could facilitate survey design and data collection.

Users of WELUT's information systems (Montgomery, personal communication; Wright, personal communication) and FWS personnel at the Salt Lake City Field Office (Bowen, personal communication) suggest that the decision to use rapid assessment methods requires organization of data at levels that had not occurred previously. Data must be organized if the system is to be used and once a system has been purchased, use is critical if the high initial costs are to be recovered. Data organization is, therefore, a necessary byproduct of using a computerized system.

One of the primary strengths of computer systems is the speed with which data can be combined and summarized. This strength is particularly valuable for resource descriptions and assessments over large areas. The cumulative hierarchical analyses described above as a CRIS application, the Gulf Coast habitat trend analyses, and the analysis of effects of stream buffer zone widths on timber harvest by the BIA all illustrate efforts that would have required orders of magnitude more time if done manually. Description, analysis, and assessment of wildlife resources can be considerably accelerated and improved by using rapid assessment methods.

Computerized procedures are particularly valuable when a large number of replications and calculations is necessary. Such replication is required to evaluate the potential impacts and benefits of an array of development and management alternatives. Overlay and compositing, buffering, statistical summary, and cartographic output capabilities all allow for rapid assessments of the effects of many alternatives and their graphical display for both internal agency use and presentation to the public in reports and at meetings. Generally, utility is moderate to high.

Because of the newness of computerized information systems, few GIS applications have been taken to the point of monitoring and re-evaluation. Projects considered when the systems first became operational are either not underway or have yet to be completed and few examples of how a GIS can assist monitoring and evaluating impact predictions are available. Cases where predevelopment data bases have been computerized are even fewer.

Remote sensing, considered by WELUT to be a RAM tool, offers a basis for assessing from the air the effects development has had on visible (and correlated) resources. Sequential aerial photography can be photointerpreted and digitized in one process without intermediate mapping (Reed, personal communication; Asherin, personal communication). Such rapid assessment methods can be used to track habitat loss and other photointerpretable effects of even very rapid development and, therefore, offer an agency the tools it needs to establish and adjust mitigation programs. Computerized methods potentially offer the same advantages in the area of impact monitoring as they do in resource evaluation.

Computer-based GIS applications are not without drawbacks, however. The first of these, the need to develop the computerized data bases, has been discussed above. Initial costs are very high. For example, it can cost several hundred to a thousand dollars to digitize the information on a single 7.5-minute USGS topographic quadrangle. Digitizing is also done by staff technicians who may not have biological training. Although they can edit obvious mistakes as they enter map data, they must rely on the field person or the original mapper to make interpretations when they require clarification. Misinterpretations can be corrected in a single step when the biologist is given the opportunity to review a rough hard-copy product but that inspection takes time. Interpretations and clarifications are made more quickly and easily when the GIS operator and biologists and mappers occupy the same offices. Therefore, PCC agency applications would be superior to "out-of-house" applications.

The three alternatives compared in Table 1-8 differ slightly in terms of the speed and efficiency of applications and the difficulties in administration. They are, however, relatively similar in terms of application costs. Initially, the costs of application would be potentially lower using one of the PCC agency systems because at least either the State of Utah's or the Wyoming BLM's data base would be in usable format and data transformation costs would be partially eliminated. On the other hand, the costs of digitizing new or original map data would probably be lower at WELUT, which employs a cadre of digitizing personnel around the clock, or an outside agency, which would typically possess an experienced, well-trained staff. The higher cost for non-PCC applications would result from potentially higher communication costs throughout the period over which project-by-project applications are conducted.

Speed and efficiency would be greater with WELUT, FWS, or outside systems because of the experience of the operators. However, the functional speed and efficiency of an outside operator could be compensated for by the need to mail products to end users and the time lost while the products are in transit. Immediate inspection of products would not be possible. Subsequent production runs would be delayed. Such losses in time and efficiency would also exist with those PCC agencies without access to the system except through the operator agency.

Administrative difficulties would probably be greater if a PCC agency system was used. For example, the Wyoming BLM does not have an administrative framework for accommodating out-of-service users (Keating, personal communication). Utah encourages counties and regional agencies to use its AGR system and may have established procedures for such use that could be tailored to fit the needs of the PCC. The operating agency would, however, have to make personnel adjustments or create a position in order to accommodate prompt applications made as part of the three-state, multi-agency agreement (which would require administrative attention at the outset). Once the initial administrative difficulties were overcome, project-by-project applications would differ little in administrative requirements.

Some problems result regardless of the alternative. For example, software also occasionally fails to work or accomplish what it is supposed to do. When the system performs without problem, the advantages over manual alternatives are fully realized. When mistakes or system failures interfere with progress on a project, the user may be inclined to return to the old, tried and true manual method, particularly if the repairs are not immediately possible. Software support (software experts available to advise and troubleshoot) is necessary if any information system is to perform to the user's expectations. When something goes wrong in manual assessment methods, the solution is likely to be apparent to the average user, but obscure computer problems and unexplained system failures can intimidate users and make acceptance difficult unless they are fully convinced of the ultimate benefits. Honest salesmanship is, therefore, an important part of system support (Darling, personal communication; Schneider and Amanullah 1979; Montgomery, personal communication).

Some perceived shortcomings in GIS applications result from unrealistic expectations. For example, maps are scale-independent in that they can be retrieved and displayed at any scale. Because the user can produce a map at 1:5000, 1:24,000, or 1:100,000 using the same computer data, it may be assumed that the real level of resolution can be changed. This assumption would lead to the faulty conclusion that the same data can apply equally well to regional and site-specific studies. If the data was originally digitized from a 1:5000 map, both applications are possible. If the map was digitized at 1:100,000, site-specific applications would be less acceptable. This problem does not, however, characterize computerized systems alone. Manual mapping fails under the same type of unrealistic demand.

RAM and GIS applications can also be supplemented by the use of other procedures. Some of these are discussed in a following section. Potential combinations of these and similar procedures are discussed thereafter.

HABITAT ASSESSMENT METHODS AND POPULATION SIMULATION METHODS

INTRODUCTION

The evaluation of habitat assessment methods and population simulation models began with a comprehensive compilation of recent (primarily post-1970) literature. Because of the extremely large number of references and methods, a three-level screening process was used to reduce the scope of the review and evaluation to a size commensurate with the available time and budget. A number of the methods and models available have been developed for physical conditions or species not found in the Bear River Divide or the Overthrust Belt. Unless they could clearly be modified for application in the study area, they were judged inapplicable and were eliminated from the review at the first level.

Twenty-five methods and models were considered applicable and received a second level of review. Initial appraisals showed that these had potential for use in Phase II of the Cooperative Wildlife Study. All have value for impact assessment or mitigation, and are adaptable to the physical and biological characteristics of the Overthrust Belt.

Each of the 25 procedures has been summarized in abstracts included in Appendix B. Specific comments discuss each procedure's applicability and pertinent related references are provided. An overview of the 25 procedures is provided in Figure 1-3, which lists the procedures on one axis of a matrix and criteria relevant to their evaluation on the other. An "x" in a cell of the matrix indicates that the corresponding procedure satisfies the respective evaluation criterion. It should be understood that some of the information in Figure 1-3 is not easily determined at this level of review, and the matrix should be viewed only as an indication of the procedure's possible utility.

Five habitat assessment methods and three population simulation models have been selected for intensive, third level of review in this report. The habitat assessment methods are:

1. Habitat Evaluation Procedures (HEP) of the USDI Fish and Wildlife Service (1980a, 1980b, 1980c, 1981);
2. Wildlife Management Information System (WILDMIS) developed at the Colorado Cooperative Wildlife Research Unit (Russell et al. 1980);
3. Wildlife and Fish Habitat Relation System (WFHR) of the USDA Forest Service (Winn 1982; USDA Forest Service 1981), which includes the General Aquatic Wildlife System (GAWS) (Duff 1982);
4. Physical Habitat Simulation System (PHABSIM) developed by the Instream Flow Group of the USDI Fish and Wildlife Service (Milhous et al. 1981); and

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5. Habitat Quality Index (HQI) developed by Binns (1979; 1982) of the Wyoming Game and Fish Department.

The population simulation models are:

1. ONEPOP population simulation model developed at the Colorado Cooperative Wildlife Research Unit (Gross et al. 1973);
2. POP50 population simulation model developed by John Bartholow (1981);
3. POSIM population simulation model developed by the Montana Department of Fish and Game (Mooney and Lonner 1978).

HABITAT AND ENVIRONMENTAL ASSESSMENT METHODS

INTRODUCTION

Generally, habitat and environmental assessment methods are used to quantitatively describe and evaluate the habitat or environment of an area. A common function is to assign a numerical value to the area based upon the quality and quantity of habitat it contains. Habitat quality is defined in different ways, but in general relates to an area's ability to supply the life requisites of a particular species or group of species. Without exception, these methods are used under the assumption that abundance or species composition of wildlife relates to habitat characteristics, and that habitat provides a measure of potential for wildlife, but other factors such as severe weather or predation may determine whether this potential is realized.

Habitat evaluation methods can be used to predict or assess environmental impacts in terms of "habitat units". Some individuals believe that impacts from environmental alterations are easier to express in terms of habitat than in terms of wildlife populations (Schamberger, personal communication) because development impact will often eliminate wildlife habitat or change its composition. Many habitat changes can be predicted in advance, while data or theory which relate such changes to wildlife population dynamics may not be available.

A habitat or environmental assessment method may specify survey techniques for collecting field data (e.g. Bovee 1980), and thereby incorporate an inventory system. All procedures which require field data rely on sample survey or censusing techniques. Reviews of these techniques, some of which are specialized, are available elsewhere (e.g. Eberhardt 1975).

TERRESTRIAL HABITAT EVALUATION PROCEDURES

Habitat Evaluation Procedures (HEP)

Description. Development of the system which evolved into the Habitat Evaluation Procedures (HEP) began in 1973. On the recommendation of a national committee composed of representatives from state fish and game agencies, private conservation groups, and the FWS, FWS began work on a system of nonmonetary evaluation of fish and wildlife resources for use in project planning. The committee recommended that the evaluation system be (Farmer 1977):

1. "community" oriented, (i.e., must address habitat values for more than just harvestable species that lend themselves to economic valuation);
2. capable of site-specific design and calibration; and

3. available to the public and scientific community for review and feedback so the system can be improved.

The committee's work began with a review of existing systems. This review led to the adoption of a procedure developed in Missouri (Daniel and Lamaire 1974) and the release of an initial publication, "Ecological Planning and Evaluation Procedures" (Joint Federal-State-Private Conservation Organization Committee 1974). After field testing, the procedures were revised and published as the "Habitat Evaluation Procedures" (USDI Fish and Wildlife Service 1976). Review produced further revisions and resulted in four core documents (USDI Fish and Wildlife Service 1980a, 1980b, 1980c, 1981) which supply the framework for current use of the method.

HEP is based on the assumption (definition) that "habitat quality" is directly related to carrying capacity. FWS defines carrying capacity as the number of animals an area will support over a long period of time (USDI Fish and Wildlife Service 1980a). However, wildlife populations experience substantial short-term fluctuations in abundance and accurate population estimates are hard to obtain. Hunting pressure, predation, and interspecies competition, which are not considered in a habitat evaluation, could limit population size. Little quantitative data exists on relationships between habitat variables and animal numbers (Schamberger and Krohn 1982). Therefore, while habitat characteristics may provide a stable indication of potential population sizes, no guarantees exist that actual populations are at those potential levels at the time of the habitat characterization.

Use of HEP requires that a habitat model be established for each species (life stage, or group of species) of interest. These are called evaluation species or guilds. According to Schamberger (personal communication), "species selected should reflect the study objectives, be sensitive to the land-use changes proposed in the study, and have meaning as ecological indicators". The model partitions habitat into resources needed by the species (called components) and subdivides each component into measurable physical and chemical variables. These variables are subjectively weighted by the user according to their significance and combined into a Habitat Suitability Index (HSI) which relates existing conditions to optimal conditions for the species:

$$HSI = \frac{\text{study area habitat conditions}}{\text{optimum habitat conditions}}$$

The ratio of actual to optimum habitat conditions expresses habitat suitability as an index with a value between zero and one. The index is assumed to have a direct linear relation to carrying capacity.

The HSI model can be constructed in word, graphical, or mathematical format, and any existing density estimates, scaled rankings, etc. could be used if they can be converted to the relative quality form. HSI models are developed in five steps (USDI Fish and Wildlife Service 1981) in which the developer:

1. sets model objectives (form of output, area and season of application);
2. determines which variables should affect the capacity of habitat to support the evaluation species, selecting for use in the model those which can be measured under existing conditions and predicted for the future;
3. defines relationships between variables and constructs the model;
4. documents the model, by specifying assumptions and equations; and
5. verifies the model to the degree possible using reviews by other authorities, field tests, and analyses with sample data.

Initial formulation of the model will likely be based upon literature and expert opinion. Variables selected should have a relationship to habitat. However, some variables are difficult to measure and selection will be subject to the limitations that time, budget, and equipment place on the application.

In defining variable relationships (step 3), four types of relationships are commonly considered (USDI Fish and Wildlife Service 1981):

1. limiting factors (variables making habitat less suitable);
2. cumulative relationships (variables act in conjunction to satisfy life requisites);
3. compensatory relationships (influence of one variable is offset by another variable);
4. spatial relationships (life requisites occur in two or more cover types).

The value of the habitat in a study area for a particular evaluation species or guild is determined by combining habitat quantity and quality according to a simple accounting system incorporated into the procedure. Normally, an area contains several cover types, each of which can have a different value to the evaluation species or guild. For each cover type, the habitat value, expressed in terms of "habitat units" (HU) equals the product of the total area of the cover type and its assessed value based on its habitat suitability rating(s) using the index (or indices). Mathematically, the relationship is

$$HU = \text{area} \times \text{HSI}.$$

Table 1-9 contains a simple hypothetical example to illustrate how HUs are calculated. The total value of the entire mosaic of cover types in HU is the sum of the products of area and habitat suitability index for each type

TABLE 1-9
HYPOTHETICAL EXAMPLE ILLUSTRATING CALCULATION OF HABITAT UNITS
USING USFWS' HABITAT EVALUATION PROCEDURES (HEP)

Cover Type	Habitat Suitability Index (HSI)	Cover Type Area (Ha)	Habitat Units (HU)
A	0.75	120	90
B	0.34	400	136
C	0.95	300	285
D	0.10	10	1
			Total HU: 512

present. Because cover type values depend on how the types are distributed with respect to one another, interspersions are also taken into consideration.

Two types of comparisons are possible using HEP: 1) comparison of the same area at different points in time; and 2) comparison of different areas at the same point in time. Comparisons of the same area at two points of time can supply the basis for predicting or monitoring natural changes in habitat or the impacts of development over the intervening period. To predict natural changes some assumptions must be made as to the rate and direction of successional processes and the frequency, distribution, and intensity of disturbances. These assumptions enable the user to estimate habitat units at some future date. The comparison requires the difference in habitat units (loss or gain) between baseline and assumed future conditions. If suitable control (undeveloped) areas exist, it is possible to monitor the effect of development by comparing HU totals and observing their relative change over time.

To predict impacts the user must decide on what the sequence of habitat states would look like with and without the human actions under consideration. The impact is the difference in habitat units gained or lost under natural conditions and under those created by man. In this case, also, the prediction is made independently of HEP. HEP only provides an accounting mechanism for expressing the impacts in the form of habitat units.

Mitigation analyses can be conducted using baseline assessments of two areas at the same time. In-kind analyses are used to determine what mitigation is required to offset losses for each evaluation species or guild. Equal replacement (equal trade-off) analyses are used when total habitat units (across all species) to be lost in one area are to be made up through replacement of an equal number elsewhere regardless of the species. Either type of analysis requires an assessment of existing conditions in both the impact and replacement areas and an assessment of the impact in the former.

The computations required for baseline assessments, impact predictions, and mitigation analyses can be done by hand. If the areas analyzed are large and a large number of development or mitigation alternatives must be considered the computations become unwieldy and may require a computer to be economically feasible. Computer programs for HEP analyses are under development. The HEP accounting software is complete and software for building and applying HSI models will soon be available (Schamberger and Krohn 1982). This software is programmed in Fortran and implemented on the Federal computer system (Schamberger, personal communication).

In addition, the Human Use and Economic Evaluation segment of HEP (USDI Fish and Wildlife Service 1980c) provides a means of assessing the extent of human uses of wildlife and associated dollar values. Impacts on habitat and wildlife species are converted to effects on projected human use.

The basic tasks to be completed in a HEP analysis are: cover type mapping, model development (or if the model exists, fine tuning to a specific application), measurement of habitat variables, and data analysis. Cover

types can be mapped from aerial photos with field verification. The amount of field verification required depends upon recency of the aerial photos.

The required time and manpower for a HEP analysis depends on the size of the study area, number of cover types, the quality and vintage of the photos used in mapping, the number of evaluation species, level of detail (and model availability) of required HSI models, and the experience of the personnel. If impacts of development are to be assessed, the number of alternative actions to be considered also affects the cost. The time required for a HEP analysis can range from a week to several months (USDI Fish and Wildlife Service 1980b) and the cost can vary by an order of magnitude.

The ease of HSI model development varies with species selected, the availability of information on the species, the type of model (word format, mathematical format, etc.), and the degree of detail required. Ideally, acceptable models exist for the species in question, and all that will be required is adjustment to fit the study area. Recently, FWS began to document HSI models to facilitate applications and to improve the reproducibility of results. A number of models have been published and many more are planned.

Models are available for six terrestrial species in the Overthrust Belt: ferruginous hawk, yellow-headed blackbird, yellow warbler, veery, Lewis woodpecker, and beaver. HSI models available for fish species in the Overthrust Belt include the cutthroat trout and the creek chub. In 1982 work began on models for carp, largemouth and smallmouth bass, green sunfish, rainbow and brook trout, and white sucker. Models for other species are planned.

Resources required to measure habitat variables will depend on the specific HSI model. Some variables can be measured directly from aerial photos and maps, while others may require extensive field measurements. Field measurements usually improve model accuracy, but they also add to the time and expense of HEP analysis.

Evaluation. HEP has been designed to assist managers in assessing wildlife habitat and quantitatively representing the impacts of development in a consistent and documentable form. As stated above, impacts must be predicted by the user and HEP only provides a basis for representing them in terms of habitat units lost or gained. In addition, HEP is the most widely applied method of habitat evaluation, and a good deal of money and manpower is devoted to continued improvement. HEP is being used or considered by FWS's Division of Ecological Services, the U.S. Army Corps of Engineers (ACE), the USDA Soil Conservation Service (SCS), and several other state agencies and private groups (Schamberger and Krohn 1982). In 1981, the Division of Ecological Services reported 112 applications of HEP (Hardy 1981).

A number of studies have been conducted to evaluate HEP. Pre-1980 versions of HEP were compared to other methods of habitat evaluation in reports by Ellis et al. (1979), Whelan et al. (1979), and Adams (1980). Kling's (1980) comparison of PATREC (Williams et al. 1978) and HEP is described below.

In a recent study (US Army Corps of Engineers 1982), ACE and the FWS jointly assessed HEP's institutional and technical adequacy on the basis of four water resource planning projects. Four general problems or shortcomings were identified. These include: 1) costs and time requirements; 2) uncertainty due to untested models; 3) complexity of collecting and processing data; and 4) the low sensitivity of the analysis. Nevertheless, the assumptions and variables used and the basic data collected for applications were considered well-documented, and the technique relatively objective and potentially comprehensive.

The ACE concluded that the institutional and technical strengths of the procedure outweigh its weaknesses and that the weaknesses could be corrected. However, until the weaknesses are corrected, HEP analyses will not be sufficiently cost-effective or credible to be used by ACE. Meanwhile, they recommended that priority be given to: 1) species model development; 2) reduction of the number of variables used in species models; 3) collection and automated storage of uniform data; and 4) design of simplified field sampling techniques.

A similar study conducted by the SCS and the FWS (Schamberger, personal communication) evaluated HEP applications on four watershed planning studies in Missouri, Oklahoma, Colorado, and Delaware. The results should be published early in 1983 but are not yet available.

Before a potential user decides to apply HEP, he should consider the balance between the costs of analysis and the quality of the results possible. This consideration can be addressed in terms of the species to be evaluated. It would not be practical to consider all occurring species in a HEP analysis, unless species are grouped (for example, in the guilding scheme of Short and Burnham 1982). Attention is focused on evaluation species or guilds of particular importance (Garst, personal communication). Due to the shortage of available HSI models and their lack of field validation, this is the most practical approach in a study with limited resources. However, the user must realize that the quality of existing habitat or the magnitude of predicted impacts are a direct product of the species or guilds selected.

Wildlife Management Information System (WILDMIS)

Description. The Wildlife Management Information System (WILDMIS) was developed by the Colorado Cooperative Wildlife Research Unit at Colorado State University (Russell et al. 1980). WILDMIS comprises several components, the most significant of which is PATREC, a method of habitat evaluation based upon the principles of pattern recognition. A description of PATREC has been published (Williams et al. 1977).

WILDMIS was developed to address a number of problems which face wildlife managers. These problems include: 1) setting production objectives; 2) evaluating habitats and assessing impacts; 3) collecting environmental data and using them to evaluate habitats; and 4) deciding which, among two or more,

wildlife management actions will provide the benefits necessary to replace affected wildlife populations at the lowest dollar cost (Russell et al. 1980).

The system focuses on individual species rather than on the wildlife community as a whole. The first step in a WILDMIS analysis is to set species priorities and to select evaluation species. A computerized ranking program called RANKER was developed to help the user systematically select species to be evaluated while using subjective ranking criteria. It allows the user to set priorities on the basis of (Russell et al. 1980):

1. ecological assessment value indicating the stability or security of the species being assessed and the extent to which the ecosystem would be disrupted if the species is removed;
2. public interest (relative aesthetic, nuisance, economics, popularity, or existence values);
3. economic value (income generating function or "willingness to sell" value); and
4. cost of management (return on investment management).

Although rankings can be based on all four elements, the ecological assessment value is most important, and species may be ranked using this single element alone.

PATREC, the core of WILDMIS, was developed using the principles of pattern recognition. Pattern recognition was first used in medical research (Uhr 1964), and in PATREC refers to the association of particular sets of habitat features with particular levels of suitability for a given species. The model developed using PATREC relies on the assumption that real and predictable relationships exist between environmental conditions and potential animal population size.

Conditional probabilities and Baye's Theorem (from mathematical probability theory) are used in PATREC to calculate the probability that an area can be assigned to a particular suitability category based on its observable habitat variables. The development of a PATREC model for application to a particular study area for one species proceeds according to a sequence of six steps. Computations are illustrated in the hypothetical example portrayed later in Table 1-10.

1. classify the habitat into one of two or more mutually exclusive "suitability categories" (i.e., suitable vs. unsuitable, high density vs. low, etc.) on the basis of subjective judgment, data, or predictions from models;
2. estimate the probabilities (referred to as prior probabilities) that sites selected at random fall in each habitat category. These prob-

abilities (relative amounts of habitat in each category) will generally be measured from maps or field studies but may also be subjective estimates;

3. given the species of interest, identify significant habitat attributes. These attributes are assumed to be statistically independent;
4. for each attribute, subjectively estimate the conditional probabilities that, given a particular habitat category, the attribute is present. These conditional probabilities may be based upon "expert" opinion but, wherever possible, users strongly recommend that they be based upon field data (e.g. Williams et al. 1977). Areas known to fit into each category should be identified and inventoried to ascertain the frequency of occurrence of each habitat parameter included in the model (Williams et al. 1977);
5. calculate the probabilities that the observed set of habitat attributes would appear, given that the site constitutes a particular category of habitat. Because the attributes are assumed to be independent, these probabilities are calculated as products of the probabilities in step four;
6. use Baye's Theorem to calculate the probability that a site is a particular category of habitat, given the observed set of attributes. This form of Baye's Theorem for two categories of habitat is:

$$P(S|E) = \frac{P(S) \times P(E|S)}{P(S) \times P(E|S) + P(U) \times P(E|U)}$$

where:

- P(S) is the prior probability for suitable habitat,
- P(U) is the prior probability for unsuitable habitat,
- P(E|S) is the probability of the set of attributes E given suitable habitat,
- P(E|U) is the probability of the set of attributes E given unsuitable habitat, and
- P(S|E) is the probability of suitable habitat given the observed set of attributes E.

This last probability, P(S|E), is called the "expected habitat suitability" (EHS) index (Williams et al. 1977). If high- and low-density categories are used then the EHS would be defined as the probability of high-density habitat.

At this point, a hypothetical example would help to illustrate how the expected habitat suitability is estimated. In this example, we will use two suitability categories, H and L, where H is the category with high population density potential and L is the category with low population density potential. The prior probabilities of these categories will be assumed, respectively, to

be 0.3 and 0.7. The conditional probabilities of the identified attributes (adequate cover, food, and water in this example), first given H and then given L, are estimated (perhaps subjectively). These probabilities are given in Table 1-10 below.

TABLE 1-10

CONDITIONAL PROBABILITIES FOR HYPOTHETICAL EXAMPLE OF PATREC

Category	Probability of the Attribute Given the Category		
	Adequate Cover	Adequate Food	Adequate Water
H = high population dens. potential	0.95	0.90	0.98
L = low population dens. potential	0.60	0.70	0.30

If a site is characterized by adequate cover, inadequate food, and adequate water, the probability that it has these attributes given that it has high population density potential (and belongs in category H) is:

$$P(E|H) = (0.95)(1.00 - 0.90)(0.98) = 0.0931.$$

The probability that it has these attributes if it has a low population density potential (and belongs in category L) is:

$$P(E|L) = (0.6)(1.00 - 0.70)(0.3) = 0.054.$$

Note that this is the step where "independence" of the attributes is assumed in each of the suitability categories.

With these calculated values, it is possible to supply the required information for the right-hand side of the above equation and to calculate the probability that the site has high population density potential given that it has the above attributes. With the values entered, the equation looks as follows:

$$\frac{P(H) \times P(E|H)}{P(H) \times P(E|H) + P(L) \times P(E|L)} = \frac{0.3(0.0931)}{(0.3)(0.0931) + (0.7)(0.054)} \\ = \frac{0.02793}{0.06573} \\ = 0.425.$$

The expected habitat suitability for this site is 0.425. The probability that the site has the potential to support a low-density population is $1.000 - 0.425 = 0.575$.

Most often only two suitability categories are defined, i.e. high density and low density. As such, PATREC provides two probabilities, the probability that a site is high-density habitat, and the probability that a site is low-density habitat. If actual numbers are associated with the high- and low-density classification, then an estimate can be obtained for the potential density on the study site will support as follows:

Estimated Potential Density at a site is estimated by the sum of two products:

$$P(\text{High}) \times (\text{High Density Value}) + P(\text{Low}) \times (\text{Low Density Value}).$$

This should be considered only a crude estimate of long-term mean density at the site. Factors not considered in the model, such as predator-prey interactions, disease, or harvest, may cause the actual density at any one time to be different.

PATREC models have specific data requirements which depend upon the species selected and models developed. However, the types of data typically used include: terrain aspect, percent slope, elevation, percentage of each vegetative type or condition, vegetation height, snow depth, percent canopy cover, and distance to water or a particular cover type (Russell et al. 1980). Much of this data can be obtained from maps or aerial photos, and could be computerized and stored in a geographic information system.

WILDMIS includes an interactive computer program (MANALT) designed to provide an orderly comparison of management alternatives. Once potential impacts have been defined and considered in relation to wildlife objectives, management plans can be compared with respect to cost, benefits produced, and likelihood of satisfying wildlife objectives. The MANALT program makes it easier and less time-consuming for a manager to consider the relative merits of various alternatives.

Most of the time, manpower, equipment, etc. for a WILDMIS application are required for the PATREC habitat evaluation. The RANKER and MANALT programs serve only as supplementary features and are run relatively inexpensively.

Although some software for a Tektronix microcomputer and coding forms have been developed at the Colorado Cooperative Wildlife Research Unit (Russell et al. 1980), computer implementation is not essential for either PATREC or WILDMIS application. All calculations are straightforward and can

be done manually. PATREC models have been computerized for mule deer, elk, and moose (Evans 1981).

Evaluation. As with any habitat evaluation, time and manpower requirements for a PATREC analysis can vary with the specific application. Size of the study area, number of evaluation species, level of detail required and availability of information are significant elements. Larger areas, more species, and greater detail increase costs. The time and manpower required to develop PATREC models can vary greatly. In a test funded by FWS (Kling 1980), the time required to develop five models based on field data was 320 person-hours per model. A sixth model based entirely on literature review and expert opinion required only 42 person-hours to develop. If models already exist for the same evaluation species in other locations, adjustments would usually be necessary to tailor the models to the specific application, but time requirements would be much reduced. The time required to implement a PATREC model depends on the data requirements of the model and data availability. Data available on maps or aerial photos will require much less time to collect and process than will field data. Objectives of a study will have much to do with the level of detail, and thus the extent of data, required.

The U.S. Forest Service has evaluated PATREC as a tool for assessing wildlife resources. The procedure received preliminary recommendation as being of potential value to the Forest Service and a review of its theoretical validity was conducted. In the review Flather (1981) stated that "fundamentally, the ecological literature offers theoretical and empirical support for the PATREC methodology", and that PATREC "represents a considerable improvement over original habitat suitability models." He does express concern over:

1. uncertain effects which failure of the assumption of independence among attributes may have on model results;
2. a need for a more tenable method of selecting habitat attributes;
3. the possibility that failure to regard species interactions may produce erroneous results;
4. possible difficulties in representing harvested populations; and
5. the possibility that density estimates from PATREC may not be appropriate for species which exhibit an opportunistic strategy for securing resources.

In 1979, the Colorado Cooperative Wildlife Research Unit and the Idaho Department of Fish and Game began a joint study and application of PATREC to an area disturbed by phosphate mining in southeastern Idaho. In the first phase of the study, PATREC models were developed, tested, refined, and computerized (Kuck 1981). The models were: winter and summer models for mule deer and elk and a year-round model for moose. Models were also developed but not tested for ruffed grouse, prairie falcon, and sandhill crane. Data

collection procedures were "aimed at speed, repeatability, and eliminating the need for extensive field data" (Evans 1981). All data required for the PATREC models were to be obtained from aerial photographs and topographic maps, or through consultation with biologists and mine company personnel.

In the second phase of the study, the PATREC models were used to obtain quantitative estimates of changes in wildlife due to phosphate mining (Evans 1981). The time frame for the evaluation was the 60-year period from 1950 to 2010. PATREC models were used to evaluate past, present, and future conditions in the study area as they would appear both with and without phosphate mining. The same type of assumptions regarding vegetation dynamics and removals required using HEP are required for a PATREC application.

Lonn Kuck (personal communication) of the Idaho Fish and Game Department is satisfied with the performance of PATREC in the Idaho study, but recognizes its limitations. The two weaknesses encountered in PATREC are the difficulty in expressing results in terms of population numbers (units of habitat loss were felt to be more valid) and the arbitrary basis for selecting model variables. Kuck also recognized that PATREC analyses can be done quite rapidly, that habitat change can be expressed quantitatively, and that the results are easily understood by non-wildlife biologists. An additional point expressed in favor of PATREC relative to the OIA study, is that the models developed in Idaho (Kuck 1981) could be adapted quite easily to the Overthrust Belt.

An illustration of the use of the WILDMIS system to assess potential changes in wildlife populations and to evaluate mitigation alternatives is presented by Russell et al. (1980). The study was designed to demonstrate the techniques rather than as a rigorous practical application. The demonstration involved 15 tracts of land in Colorado and Utah which were believed to have potential for oil shale development. PATREC models developed for eight species (mule deer, elk, mountain lion, golden eagle, peregrine falcon, sage grouse, mountain bluebird, and mallard) were used to estimate potential population losses due to different development scenarios. MANALT was used to compare the costs and benefits of various management actions.

The WILDMIS system has the potential to serve a number of functions in a study of the effects of energy development on wildlife. The RANKER program could be used to assign priorities to wildlife species in development planning. Habitat evaluation with PATREC would allow prediction and assessment of impacts, and could be used to compare development alternatives for mitigation of impacts. As used in an area of phosphate mining in Idaho (Kuck 1981), it is possible with PATREC to subjectively evaluate development which has already taken place and to consider future development in light of natural changes. The MANALT program could be used to subjectively facilitate comparison of the costs and benefits of management alternatives in mitigation.

The principle deficiencies in the WILDMIS system would appear to be limited field verification and the limited number of existing models. Also, as mentioned earlier in this report, researchers have expressed some theoretical and practical concerns with PATREC. WILDMIS is not unlike other existing

methods for habitat evaluation in its need for further research, particularly field verification.

Wildlife and Fish Habitat Relationship (WFHR)

Description. During the last four years, the U.S. Forest Service has put substantial effort into the development of a system that can be used to integrate "fish and wildlife information and assessment data into the interdisciplinary land and resource management process" (USDA Forest Service 1981a). The system is called Wildlife and Fish Habitat Relationships (WFHR). The development of WFHR originated with the work of Thomas (1976, 1979) in Oregon and Washington. Although the basic concepts are shared throughout the Forest Service, each Region proceeded independently in its development of WFHR and the systems are quite variable.

The core of the WFHR system is a large data base which contains regional information on terrestrial and aquatic vertebrate species and their habitats. Information in the system is compiled from literature, as well as the experience, unpublished files, and records of Forest Service biologists. Species-habitat relationships in WFHR are displayed in matrices in which the cell values between zero and one indicate the strength of the association between a community type shown along one axis and a species' requirements for reproduction, feeding, and nesting shown on the other.

The WFHR system actually combines several different procedures designed to produce the information on timber, wildlife, water resources, forage, etc. the Forest Service uses in its multi-resource management (Salwasser, personal communication). Substantial studies necessary to characterize an area's habitat attributes can include detailed analysis of plant species composition, vegetation structure, and the amount of downed timber. Use is evaluated through pellet counts, small mammal trapping, and bird surveys (Winn, personal communication). Species richness and diversity indices may be calculated as indicators of habitat quality. Forest succession models may be incorporated to predict future conditions when considering timber management alternatives or when necessary to mitigate development impacts.

WFHR is directed to large-area (regional) concerns, with consideration for all vertebrate species. However, HSI (USDI Fish and Wildlife Service 1981) or other habitat models may be included in the analysis when individual species merit close attention (Salwasser, personal communication).

The Intermountain Region (Region IV) based in Ogden, Utah, and the Rocky Mountain Region (Region II) based in Denver, Colorado, which include the Overthrust Belt, have developed WFHR systems that fit the above description. Both regions have computerized their systems and run them on the Forest Service computer in Fort Collins, Colorado, using the same software. However, the two systems are not identical, and have been described separately in abstract form in Appendix B (Winn, personal communication). A comprehensive system for aquatic analysis (GAWS) has been developed as part of WFHR in Region IV, and is reviewed in detail.

Both Region II and Region IV use the Quick Query data base management system developed by Consolidated Analysis Centers, Inc. (CAC, Inc. 1975). Quick Query can be used to analyze data, but its primary function is searching of the species-habitat data files. Information can be retrieved from the data base on specific species, or community types, or corresponding species-community associations. For example, if a proposed action is likely to replace one community type with another, the data base can be searched for information on all species which occur in the existing community and the likely effects of the change (in terms of the area's ability to satisfy the species' various needs for feeding, reproduction, and cover) can be identified. Such information is useful in identifying species of concern, as well as in identifying and mitigating potential impacts of proposed development or management actions.

Most WFHR applications have been related to timber management decisions as they affect fish and wildlife. Examples are reported by Winn (1980) and Sheppard et al. (1982).

Sheppard and her coworkers applied WFHR to a proposed mining project on the Gunnison National Forest in Colorado and developed a method for using it to analyze seven project alternatives involving different combinations of mine and mill sites, access routes, production rates, land exchange and mitigation measures. An "impact index" was used in the analysis to represent acres lost and the decreased capacity to supply wildlife needs for feeding, nesting, and reproductive habitat. In the analysis:

1. alternatives were compared in terms of habitat disturbance although wildlife species remained the units of importance;
2. all vertebrate species potentially occurring in the project area were considered equally;
3. each vegetation type was considered in terms of its value as habitat for all species (rather than special species) and the possible importance of relatively scarce vegetation types in limiting wildlife distributions was taken into consideration;
4. impact index values as calculated are specific to species and local vegetation considered.

Evaluation. WFHR is available for general use and could be used in any forested area and, though not to as great an extent, in grassland and shrub communities. The data base for Region II has been published in two volumes (USDA Forest Service 1981), the second of which is stored on the Forest Service computer in Fort Collins, Colorado and contains species-habitat matrices. WFHR information in Region IV is also computerized, and requests for specific output can be made to the Fort Collins office (Winn, personal communication).

WFHR appears to have strong potential for use in environmental evaluations. Any land use proposal which can be assessed in terms of specific habitat changes it would cause could be evaluated with the WFHR system, provided the area concerned is suitably represented by a Forest Service data base. WFHR provides a rapid means of summarizing the value of habitat to all vertebrate species, though not necessarily in the quantitative form of other methods of habitat evaluation. Proposed actions can be assessed in terms of changes in species occurrence and habitat potential for satisfying life requisites.

Difficulties in applying WFHR would result from limitations in the data base which provides the foundation for the system. The data are strongly oriented to forested communities but broader application would be possible if more data from nonforested communities were included. Some effort is, in fact, being made by the Forest Service in Region II to coordinate the system with those of other resource agencies (Sheppard, personal communication). Incorporating rangeland data from the BLM would be one possibility for broadening the system. The greatest shortcoming of the data base is a lack of field validation, but this should become less of a concern in the future. As its use continues, the Forest Service plans to monitor and refine the system (Sheppard, personal communication; Salwasser, personal communication).

SUMMARY EVALUATION OF TERRESTRIAL HABITAT EVALUATION PROCEDURES

In a study for the FWS, Kling (1980) attempted to assess the relative utility of PATREC and HEP (as it had evolved by 1979) for evaluating terrestrial wildlife habitat. PATREC models were developed for six species (mule deer, pronghorn antelope, sharp-tailed grouse, sage grouse, golden eagle, and Brewer's sparrow) and field-tested on an area north of Sheridan, Wyoming, where existing population estimates could be used as habitat quality benchmarks. Field testing revealed considerable variability in the quality of estimates produced by both PATREC and HEP. Kling stated:

"Neither PATREC nor the Handbook (HEP) models performed consistently or accurately among all areas and species tested so there can be no absolute statement concerning the relative practicality of one or the other on ability of the procedures or models to accurately predict habitat quality."

In fact, neither method produced estimates that were consistently superior to those based simply on personal opinion. As a group, the state, federal, and private-sector biologists that participated expressed no definitive preference for either PATREC or HEP. The calculations required for the PATREC analysis were considered easier and less time-consuming than those for HEP. Kling concluded that PATREC is "at least as practical" as HEP for habitat evaluation, but that "a considerable amount of work remains to be done on methods to evaluate habitat quality".

A summary evaluation and comparison of the three procedures is given in Table 1-11. Table 1-11 shows that each of the three procedures is subject to

TABLE 1-11
SUMMARY EVALUATION AND COMPARISON OF
TERRESTRIAL HABITAT EVALUATION METHODS

	HEP	WILDMIS	WFHR
Applicability to the Overthrust Belt	Moderate	Moderate	Moderate to Low
Sensitivity for identification of environmentally sensitive areas	Moderate to Low	Moderate to Low	Low
Sensitivity for impact prediction	Moderate to Low	Moderate to Low	Low
Dependence on subjective judgment	High	High	Moderate
Field testing and evaluation	Low	Low	Low
Utility in evaluating reclamation and mitigation practices	Moderate to Low	Moderate to Low	Low
Number of applications	High	Low	Low
History of successful applications	Poor	Fair	Poor
Accessibility of the model	High	Moderate	Moderate
Time and manpower requirements	High	High	High
Commitment to continued development	High	Unknown	High

severe criticism. No procedure has been endorsed as a result of rigorous testing and evaluation. This depends heavily on subjective judgement, and limited data of occasionally poor quality. In general, the procedures were developed to support management decisions on alternative actions (for development of an area) in the absence of sound scientific studies. Managers will always find themselves in this undesirable position. However, decisions will be made (with or without the backing of scientific studies) and the habitat evaluation procedures which were reviewed are the best available for: 1) rapid use of available data, however sparse it may be, (e.g., photographs, maps, regional data bases) and 2) quantification of prior knowledge and experience (e.g., subjective evaluation of "habitat units" in HEP and "expected habitat suitability" in PATREC).

The reviewers prefer HEP over WILDMIS and WFHR, primarily because of the assumption of independence of attributes made in WILDMIS when computing conditional probabilities required in Baye's theorem, an unknown commitment to continued development of WILDMIS, the limited applications of WFHR in grassland and shrub communities, and the inadequate quantification of prior knowledge and experience in WFHR. Thus, the choice is the lesser of evils. On the positive side, HEP has been widely applied, allows relatively rapid use of available data, and subjectively quantifies prior knowledge and experience for use in the decision-making process. Available data, prior knowledge, and experience are summarized in terms of Habitat Units (HU) to assist managers in assessing quality of habitat and qualitatively measuring the effects of development impacts, reclamation, and mitigation.

AQUATIC HABITAT EVALUATION PROCEDURES

Physical Habitat Simulation System

Description. The Physical Habitat Simulation System (PHABSIM) has been developed since 1976 by the Cooperative Instream Flow Service Group (CIFSG) of the FWS. Today it has become an integral component of the Instream Flow Group's Incremental Method, a broad-scale computerized decision-making process.

The system was developed to simulate and quantify available microhabitat for a variety of fish species and life phases under differing flow regimes, water quality conditions, and physical channel structures (Bovee 1978; Milhous et al. 1981). PHABSIM has been applied over a wide range of stream sizes throughout the continental United States, but most of the applications have been centered in the Rocky Mountain states of Wyoming, Utah, Colorado, Idaho, and Montana (CIFSG 1979).

PHABSIM produces an estimate of weighted usable area of instream habitat for the fish species, life phases, and discharges under investigation. Four general steps are followed to arrive at the end product:

1. field measurements of water depth, velocity, substrate and cover are made using transects at one or more levels of flow in the selected study reach (Bovee and Milhous 1978).
2. using hydraulic simulation, the composition of the study reach in terms of water depths and velocities in association with the substrate types present is estimated for a wide range of flow levels. Bovee and Milhous (1978) provide a detailed discussion of hydraulic simulation techniques.
3. habitat suitability curves are then developed for the species and life stages under investigation, or published curves, such as those developed by Bovee (1978) for the Salmonid family, are used. On a scale of 0.0 to 1.0, these curves provide a rating of the relative value of given types of physical habitat based on water depth and velocity and substrate conditions.
4. applying the habitat suitability ratings to the hydraulic data obtained in step 2, weighted usable area is then calculated for each discharge, species, and life stage under investigation. Bovee (1978) suggests that the weighted usable area is a rough estimation of the habitat's carrying capacity based upon its hydrologic and physical features. Data presented by Bovee et al. (1979) for brown trout in southeastern Wyoming tend to support this suggestion.

PHABSIM and the Incremental Method were designed primarily to evaluate changes in weighted usable area, standing crop, and species composition in relation to changes in discharge for instream flow and water management analysis. However, several other possible applications of the method have been identified by Bovee (1978, 1982) and Milhous and his coworkers (1981). These include: (1) impact analyses for channel modification projects; (2) costefficiency analyses for habitat improvement projects; (3) stream classification and stocking programs; (4) negotiation of operating schedules for hydroelectric facilities; (5) predictions of possible shifts in species composition in relation to channel alterations; and (6) area-wide planning. The CIFSG (Cooperative Instream Flow Group 1979) reports that within two of its original developments, the Incremental Method had been applied on 339 stream reaches throughout the United States by a variety of state and federal agencies.

The BLM (USDI 1979) has recommended that the method be used in situations which might involve legal or political challenge or when it is desirable to examine a number of management options to achieve the best mixture of values gained or lost. The BLM considers PHABSIM the most scientifically and legally defensible method available for most instream flow problems and supports it as the best method for assessing the potential impacts of streamflow alterations and different management alternatives.

The PHABSIM simulation program is written in Fortran and contains two primary subroutines, the Hydraulic Simulation Sybsystem and the Habitat Simu-

lation Subsystem. Milhous et al. (1981) present detailed discussions of both subroutines and the program's hardware requirements in their "User's Guide to the Physical Habitat Simulation System (PHABSIM)". The model requires a CDC Cyber computer and is currently available for out-service users through the computer facilities of the Colorado State University, Fort Collins, Colorado.

The Hydraulic Simulation Subroutine provides a mathematical description of the physical characteristics of a stream reach. Three hydraulic simulation computer programs are currently available in the subroutine to predict or calculate stream depth, velocity, width, wetted perimeter, and water surface elevation. These programs, IFG-1, Water Surface Profile, and IFG-4 manipulate field-collected hydraulic input data to provide hydraulic information over a varying range of simulated stream discharges. In essence, these programs use data collected at only a few flow levels to provide the user with a physical "picture" of the stream reach over a much broader range in flow levels. The precision and accuracy of the picture depends on the choice of stream reach, transect placement, and quality of the field data collected.

The Habitat Simulation Subroutine is used to translate changes in stream flow levels into effects on fish habitat. This subroutine must be supplied two general types of input data. One of these is the output of the Hydraulic Simulation Subroutine (i.e., water depth, water velocity, and substrate composition of the study reach at each of the flow levels of interest). The other is a set of habitat suitability curves for the species, life functions (e.g., spawning, rearing, passage), and life stages (egg incubation, fry, fingerling, adult). Prototype curves for the Salmonid family were developed by the CIFSG (Bovee 1978), but users must develop and maintain curves that apply specifically to the species and stream reaches in their study areas.

The habitat suitability curves are based on the assumption that individuals of a species tend to select the most favorable conditions available within a stream. As conditions become less favorable in a particular area or reach, individuals will use it less frequently and will leave it before a lethal condition develops. Generally, curves are constructed based upon the frequency of observation of a species inhabiting various stream areas. The assumption is that the number of unbiased observations of a species in a particular habitat indicates the habitat's suitability. Weighting factors from 0.0 to 1.0 are then developed from these observation data, with 1.0 indicating continuous use and optimum habitat.

Using hydraulic simulation subroutine output and habitat suitability curves, the Habitat Simulation program then multiplies the area of different depth-velocity-substrate combinations in the study reach at each flow level of interest by the appropriate weighting factors. The sum of the products is the weighted usable area for the reach. This procedure roughly equates the total surface area to an equivalent area of optimal habitat. Plotting programs are then available to display weighted usable area against discharge level.

Evaluation. To effectively use PHABSIM, the CIFSG recommends that the user complete several of its training courses on field data collection and

computer analysis techniques. With a method as complex as PHABSIM, general cost and time estimates would be virtually impossible to estimate. Both cost and time depend upon the training and background of project personnel, as well as the scope of the study and the characteristics of the stream under investigation. The CIFSG (Cooperative Instream Flow Group 1979) provides some guidance in this area, stating that preliminary estimates of the time and costs required to collect the field data necessary to operate PHABSIM ranges from two to six person-days and from \$500 to \$1,200 per reach.

Because of its broad application potential and the anticipated nature of stream habitat-related problems in the Overthrust Belt (e.g., possible flow alteration and physical channel degradation), PHABSIM would be suited for later work in the OIA's Cooperative Wildlife Program. Although PHABSIM has been used primarily to quantify instream flow volumes necessary to protect aquatic habitats under state and federal laws (Wesche and Richard 1980), the method can also be used to quantitatively evaluate impacts which have occurred (i.e., before-after studies), predict impacts which might occur as a result of various proposals for development, identify critical or sensitive habitat for particular species, and assist in weighing the merits of various mitigation alternatives. The effectiveness of PHABSIM in addressing certain of these applications is illustrated in the following brief case histories (Cooperative Instream Flow Group 1979).

Several examples illustrate the use of PHABSIM. For the Foothill Water Treatment Plant in Colorado, negotiations over a construction permit for the plant and associated dam had been deadlocked for several years. Applicants for the permit and opponents of the project could not agree on the instream flow needed to mitigate the adverse effects of the project. PHABSIM was used to estimate the magnitude of habitat losses among alternative flow releases and provided the basis for settlement between the parties. Also, PHABSIM output products were used to demonstrate the potential habitat that could be gained by altering channel configurations below the dam and to obtain funds for habitat improvement. PHABSIM was also used in Colorado to evaluate ten alternative designs for the San Luis Conveyance Channel to determine which would provide the best brown or rainbow trout habitat.

In North Dakota additional water storage facilities were proposed on the Green River. In the development of the mitigation plan, two models were used to assess the project. The first was a temperature model used to determine whether or not the thermal regions of the river would be suitable for stocking trout. The temperature regime was found to be suitable. However, when the second assessment model (PHABSIM) was applied to the data, it was found that under the proposed release schedule, there would be only limited trout habitat available and that under any flow regime, spawning in the river would be doubtful. As a result, the mitigation plan called for greater release from storage, annual stocking of fingerling rainbow trout to compensate for the lack of spawning habitat, and deepening of existing pools to provide additional habitat.

Over the past several years, the Incremental Method and PHABSIM have been evaluated on their own merits, but also several studies have been conducted to

compare their output products with those of other methods as the bases for making instream flow recommendations. Prewitt and Carlson (1980) compared the Tennant Method, R-2 Cross (Forest Service), Water Surface Profile, and the Incremental Method on the White and Yampa Rivers of Colorado for the Colorado squawfish and channel catfish. The authors concluded that the four methods required approximately equal time and cost inputs, but that the Incremental Method offered the greatest analytic advantages.

A similar study (Nelson 1980) conducted in Montana produced slightly different results. Nelson concluded that, in its present state (1980), the Incremental Method was not a consistent method for deriving instream flow recommendations for Montana trout rivers. To improve the consistency, Bovee (1982) recommended:

1. that the model use bottom velocities rather than mean velocities in the water column to compute the weighted usable area;
2. that habitat suitability curves be developed from data collected for river populations of trout; and
3. that the model incorporate cover.

Since this report was written, the CIFSG has modified the method in accordance with the latter two recommendations (Bovee 1982).

As with any method, the extent to which the underlying assumptions are met determines the validity of the end products. Orth and Maugham (1982) list and discuss five inherent assumptions of the Incremental Method in light of their experience with the method on Oklahoma warmwater streams:

1. depth, velocity, and substrate most strongly affect fish abundance and distribution;
2. the channel is rigid and well-defined (not altered by changes in the flow regime);
3. depth, velocity and substrate are independent in their influence on selection of habitat by fish;
4. one representative sample reach is all that is needed to model the stream; and
5. there is a direct, positive relationship between weighted usable area and standing crop of fish or habitat use.

The authors conclude that the first assumption can be quite tenuous, especially when applied to flows altered by impoundments. Reservoirs can alter normal chemical conditions, temperature regimes, and the type of organic matter, thereby giving these factors greater importance in terms of the effects on downstream fisheries.

The second assumption can never be strictly adhered to because even in boulder and bedrock channels, degradation will eventually occur and morphology will change (Simons 1979).

Orth and Maugham tested the third assumption (independence of habitat-suitability curves) with the data they had collected on three warmwater minnow species and found it to be invalid. At higher discharges in the study streams, the apparent amount of weighted usable area for the three species declined more rapidly than it would have if interaction had been considered. Also, the fourth assumption was not strictly met because deep, sluggish pools (a minor habitat type in the study stream) were not found in the reach selected for study. The authors believe that further research, such as Bovee and Milhouse (1978) have begun, is needed to establish the most efficient sampling schemes and the correct number of study reaches.

Regarding the fifth assumption, Orth and Maugham conclude that the relationship between weighted usable area and standing crop must receive further testing. At this time, too little data exists upon which generalizations can be made regarding its validity.

Although PHABSIM has problems in regard to the validity of its assumptions, this model is the leading stream habitat assessment method. It will continue to undergo much more rigorous inspection than other models, in part because of its position at the forefront, in part because it was originally developed to perform in the multi-disciplinary water management and allocation arena. It was developed to be applied, analyzed, and evaluated by fisheries biologists dealing with general habitat problems.

Habitat Quality Index

Description. As a result of recent legislation requiring economic and environmental assessment of land- and water-related resource development projects, the Wyoming Game and Fish Department developed a standard procedure for evaluating fluvial habitat quality based on the relationship between habitat and trout standing crop (Binns 1979, Binns and Eiserman 1979). The procedure is called the Habitat Quality Index (HQI). Primarily developed to evaluate aquatic habitat, HQI has also been used to assess habitat improvement potential, predict trout standing crops, evaluate habitat degradation or alteration, and provide support for instream flow recommendations by quantifying changes in standing crops at various discharges (Binns 1982). HQI application is restricted solely to habitat quantification with respect to members of the Salmonid family, particularly brook, rainbow, brown, and cutthroat trout (Pistono 1982).

HQI was developed from data collected on 36 Wyoming trout streams (Binns 1979). Twenty-two physical, chemical, and biological habitat attributes were evaluated at each of 44 sites in a statewide study. Twenty-one study sites were established in the Bear, Wind, Sweetwater, Green, and Snake River drainages, 18 in the upper North Platte River and Little Snake River drainages, two

in the Tongue River drainage and three were set up in the Belle Fourche River drainage.

In subsequent multiple regression analyses, 11 of the 22 habitat attributes tested displayed significant correlations to study stream trout population estimates (Binns 1979). HQI was developed from these statistical tools. Continued testing and refinement of HQI has led to the development of two predictive models (called Models I and II). Field applications of both models on each of the 44 initial study sites indicate that Model II is most reliable and explains a greater percentage (96 percent) of the variation in trout standing crops (Binns 1979). Currently, the Wyoming Game and Fish Department's Aquatic Habitat Crew uses Model II to evaluate fluvial habitat (Binns 1979; Pistoro, personal communication). Although HQI is presently restricted to applications involving members of the Salmonid family, it could be modified to apply to species other than trout (Binns 1979). No such application, however, has been made (Pistoro, personal communication).

Both Models I and II require similar data, expertise, and site-specific field data to ensure reliable performance (Binns 1982). The underlying assumptions are that all data are independent and are collected at randomly selected sample sites on a stream, and that the collection process produces unbiased estimates of the habitat parameters included in the model (McDonald, personal communication).

The data required to run HQI are obtained through field measurement of the following habitat parameters:

1. late-summer stream flow;
2. annual streamflow variation;
3. maximum summer stream temperature;
4. nitrate nitrogen concentration;
5. fish food abundance;
6. fish food diversity;
7. cover;
8. eroding streambanks;
9. water velocity;
10. stream width; and
11. substrate composition.

The primary difference between the models is the method used to assess the nutritional component of food availability. Model I uses data on macro-invertebrate abundance and diversity to evaluate the potential food base and requires the collection and analysis of numerous field samples. Model II, however, uses maximum summer stream temperature, nitrate nitrogen concentration, substrate, and water velocity, together to create an indicator of the potential food base (Binns 1979). This indicator, called the "food index", was developed through statistical procedures and its use has resulted in improved model performance and a significant reduction in time, cost, and staffing requirements.

HQI field evaluations are typically conducted in late August through September during critical low-flow periods. This period is termed "critical" in the Rocky Mountain Region because of the possible stress to trout by low stream flows, limited cover availability, increased water temperatures, and decreased water velocities. Also, "conditions for sampling habitat attributes are usually optimal at this time" (Binns 1982).

Field stations are established on selected stream reaches that represent the fluvial habitat present in the study stream. Prior to study site establishment, the three habitat attributes of maximum summer stream temperature, later summer stream flow and annual stream flow variation are evaluated from existing federal-state gauging station records. If flow records are unavailable for a stream under investigation, they are estimated "by close observations of existing conditions, and from physical evidence, such as high water marks and silt deposits" (Binns 1979).

After representative study sites have been established, estimates of the remaining habitat parameters are obtained using transect evaluation following procedures described by Bovee and Milhous (1978). Each study site is subdivided into at least 10 equally spaced cross-sections in which water width and depth and substrate measurements are made. Water samples are collected for later nitrate nitrogen concentration analysis. Cover and eroding stream banks are evaluated through bank measurement with the sum obtained divided by the total length of the study section (Binns 1979, Binns 1982). Field habitat data collected for each parameter are then compared to statistically derived intervals and assigned a numerical value of 0, 1, 2, 3, or 4, where 0 represents a poor condition, and 4, an excellent habitat ranking. An HQI score, e.g., predicted trout standing crop, is then computed by applying the attribute values to the model selected for use.

Evaluation. Standard HQI model output is the predicted trout standing crop in pounds of fish per surface acre of stream. One additional calculation provides the user with what are termed "trout habitat units". A trout habitat unit is defined as "the amount of habitat quality required to produce an increase in the trout standing crop of one pound/acre (Binns 1976, 1978, 1979). In an investigation of the potential impacts of Cheyenne's proposed Stage II water diversion project, Miller (1980) used HQI to assess numerous streams to be developed by the project. Results of this investigation were reported as changes in habitat units through comparison of pre- and post-con-

struction conditions. As a result of the study, the initial Stage II development proposal was found unacceptable due to "lack of adequate maintenance and flushing flows below the diversion structures and fish habitat destruction in Hog Park Creek, Encampment River, and Middle Fork of Crow Creek".

Jespersion (1979) examined the HQI criteria during an instream flow investigation of the North Fork and Roaring Fork of the Little Snake River in Wyoming. He concluded that the parameters used in the HQI model were, indeed, "the most important factors for predicting trout standing crop" in that situation.

HQI applications by the Wyoming Game and Fish Department have provided reliable estimates of habitat quality and trout standing crops on numerous streams in the state (Binns 1979, 1982; Pistono, personal communication). HQI has proven especially useful in the evaluation of large streams where conventional electrofishing is not possible because of stream size and water quality constraints. Binns (1978) applied the HQI to predict that the trout standing crop in the Lower Green River would decrease from 64 to 8 kg/hectare if the stream flow regime was decreased from 45 to 8.5 m³/second. This prediction supported an instream flow recommendation reported elsewhere on the Green River (Banks et al. 1974).

Additional HQI applications include a study conducted on the North Fork of the Little Snake River to assess the potential changes a proposed trans-basin water diversion would have on indigenous populations of Colorado River cutthroat trout (Binns 1977), and an investigation assessing habitat improvement/degradation potential on Huff Creek (a tributary of the Bear River in southwestern Wyoming), which contains a population of the rare Bonneville cutthroat trout. In both examples, results obtained through HQI evaluation proved valuable in debates on project feasibility and instream flow requirements (Binns 1979).

HQI computer hardware and software requirements are minimal. Model I and II calculations can be performed on a desk-top calculator. Two programs are available, however, for HP25C and HP67 calculators (Binns 1982). Personnel requirements are also minimal; two experienced crew members capable of obtaining HQI field measurements in 2-3 hours (Binns 1982) are necessary. Proper application of the HQI nevertheless requires a thorough understanding of trout, trout streams, and the life history requirements of the species being evaluated. An experienced fisheries biologist should have little difficulty in learning and successfully applying the HQI technique in the Rocky Mountain region.

Although various methods have been developed and applied in aquatic habitat evaluation studies, many such as PHABSIM or GAWS (described next), require considerable equipment and field data collection. The flexibility and favorable history of application displayed by HQI, its minimal equipment and staffing requirements, and rapidity of application, make it a procedure well-suited to energy-related aquatic habitat investigations in the Overthrust Belt.

General Aquatic Wildlife System (GAWS)

In 1975, the Intermountain Region of the U.S. Forest Service developed the General Aquatic Wildlife System (GAWS). GAWS is the aquatic component of the Wildlife Resources Allocation Model (WILDRAM), a large fish and wildlife computer storage, retrieval and analysis system. It was designed primarily for application in the Rocky Mountain area.

GAWS was developed to inventory, describe, monitor and predict current habitat conditions, and vulnerability of that habitat to impact (Duff 1982). It currently consists of Stream Habitat Surveys, Lake Habitat Surveys, Macroinvertebrate Surveys, and Instream Flow Analysis. Presently, the Stream Habitat Survey, Macroinvertebrate Survey, and Instream Flow Analysis components of the GAWS program are fully operational. Complete operational status is expected by the mid-1980s (Duff 1982).

Computer hardware and software requirements appear extensive. Currently, applications can be conducted only on the Control Data Corporation's CDC 3200 computer located in Ogden, Utah (Dunham and Collotzi 1975, Duff 1982). Access to GAWS software is currently restricted to federal agencies, but plans are underway to make this system available to out-service users in the near future (Duff, personal communication).

Stream Habitat Surveys. Stream Habitat Surveys are conducted using transects (Bovee and Milhous 1978). Two separate forms have been developed by the Forest Service for recording and organizing collected data. The Stream Station Transect Form is completed in the field at the time of the survey (Dunham and Collotzi 1975), and the Stream Identification Form is completed later in the office.

The Stream Identification Form requires descriptive information such as stream name and location, forest, stream order, and stream length. The Stream Station Transect Form is used to record numerous hydrologic and morphologic habitat parameters that are estimated, including channel and stream width, stream bank stability, vegetative cover, channel substrate composition, pool and riffle class, and pool and riffle quality (Duff 1982). GAWS stream habitat surveys are restricted to applications on streams of from 1 to 45 meters in width and the evaluations are presently confined to Salmonid habitat (Duff 1982).

Each habitat parameter is evaluated at five transects spaced at equal intervals within a predetermined stream study station. Study station selection is based on the stream's physical characteristics (Dunham and Collotzi 1975, Duff 1982). The survey can be conducted at one of four levels of intensity each of which currently is designed for a particular level of planning and management activity. Increasingly more data is needed at each higher level. Each survey level and its appropriate area of application can be described as follows:

1. Level I Survey - identification-level survey with minimal data requirements; applied to large geographical areas using office procedures and data obtained from existing federal, state or local government files;
2. Level II Survey - reconnaissance-level survey to evaluate the primary habitat attributes of spawning, rearing, cover and habitat improvement capability; applied to single watersheds or individual stream reaches;
3. Level III Survey - a planning-level survey which requires extensive transect analysis to provide information on which land management prescriptive recommendations can be made; and
4. Level IV Survey - a site-specific survey requiring more transects and inventory data; applied in implementation, monitoring, or evaluation activities.

The product of a Stream Habitat Survey and computer analysis is a computer printout (Habitat Percent of Optimum Survey) containing habitat information on the several streams or stream systems surveyed. Summarized habitat information includes stream name and geographical description, station and sample number, stream gradient, geological landform description, and percent of optimum for pool and riffle ratio, pool structure, stream channel bottom, stream environment, habitat, and bank stability (Duff 1982).

Lake Habitat Surveys. The Lake Habitat Survey portion of GAWS is currently non-operational. When it becomes operational, it will also offer four survey levels; in this case, for evaluating the habitat characteristics of limnetic waters (Duff 1982).

Macroinvertebrate Surveys. The GAWS macroinvertebrate surveys can be used to assess both the abiotic and biotic qualities of instream and riparian habitat through macroinvertebrate analysis (Duff 1982). The method is designed to assess a stream's condition and uses dominance and diversity data obtained from transect samples (Duff 1982).

Data is acquired from three samples collected at each of the five transects established per field station. Species dominance and taxonomic diversity index and abundance and dry weight biomass are calculated for each sample and entered into the computer for analysis (Duff 1982). Output in the form of a computer printout lists the following information:

1. species analysis list providing taxonomic information from class to species;
2. tabulation of the mean weight of species per square meter;
3. species logarithmic functions; and

4. summation statistics pertaining to the entire sample.

The macroinvertebrate survey computer analysis can also provide the Biotic Condition Index (BCI). The BCI is calculated from statistical and diversity index data and reports both the current and potential stream condition in quantifiable terms.

As reported by Duff (1982), "the BCI is helpful to evaluate stream conditions based on its own potential and to define management strategies for that stream."

Instream Flow Analysis. The instream flow portion of GAWS is used to measure and evaluate the potential availability of trout habitat based on species-specific criteria (Duff 1982). The instream flow model assumes that a habitat-discharge relationship can be used to recommend minimal streamflow requirements on Rocky Mountain streams between one and 45 meters wide (Duff 1982).

Model input requirements include both hydraulic and aquatic habitat data. Hydraulic data include water depth and width, water velocity, and stream gradient. Aquatic habitat data required by the model are streambank cover and stability, pool-riffle area and quality, and channel substrate composition. The model can provide data on stream channel profiles and aquatic habitat flow in tabular or graphic format.

Evaluation of GAWS. GAWS is primarily used by personnel in Region 4 of the U.S. Forest Service. Additional applications have been made by Rocky Mountain area BLM and FWS offices (Duff, personal communication). As previously stated, both the Stream Habitat Survey and the Instream Flow components of GAWS have been in use since 1975 (Duff, personal communication). Although the system has not been extensively employed by out-service users, the Forest Service is currently including State Wildlife Agency code numbers for waters surveyed, but not administered by the Forest Service (Duff, personal communication). Future availability of GAWS for inter-agency use, therefore, appears promising.

Field and office equipment, time, and staffing requirements are very similar to those necessary for most aquatic habitat evaluation studies utilizing the transect method of analysis. The individual type of survey as well as the level of survey employed will, however, dictate the exact requirements of the study to be performed. Field crew personnel should have extensive biologic and hydrologic knowledge to ensure proper study station selection and accurate parameter assessment. The Forest Service is currently developing field forms which will coincide with each of the four GAWS procedural methods (Duff, personal communication). Such forms will not only facilitate data organization, but will also expedite data entry into the appropriate computer model.

Due to both its recent development and restricted availability, reports on GAWS applications are not common in the literature. Several studies using the instream flow model have, however, been conducted with favorable results.

Rose and Johnson (1976) evaluated the performance of three instream flow models on the Strawberry River, Utah, a blue-ribbon trout stream affected by the Bonneville Unit of the Central Utah Water Project and reported GAWS as being an effective tool for determining instream flow requirements in spite of its expense and time requirements.

In another study on streams in the Uinta and Ashley National Forests in Utah, Chrostowski (1972) used GAWS instream flow methods to recommend flow volumes required to sustain a natural fishery. According to Duff (1982), the instream flow methods have been extensively applied in the Rocky Mountain region and have maintained their credibility in water adjudication court cases. No specific examples, however, are currently available for review.

While the instream flow component of GAWS does appear to be a valid technique for making stream flow recommendations, the mitigative and predictive capabilities of the Macroinvertebrate and Stream Habitat Survey procedures remain unclear. Although the statistical reliability of the model output is unknown, the GAWS procedures do appear to have been developed from scientifically sound principles. Until more applications have been reported, further review will not be possible.

SUMMARY EVALUATION OF AQUATIC HABITAT EVALUATION PROCEDURE

The field of aquatic habitat evaluation is relatively young and has been characterized by the development of a large number of procedures and, consequently the absence of standardized measurement and evaluation techniques. Also, because of the youth of the field, little exists in the way of information which can be used to comparatively evaluate not only the set of procedures evaluated in this report but the entire set of available methods as well. Some comparisons can, however, be made between the PHABSIM, HQI, and GAWS based on the review conducted here. These comparisons are summarized in tabular form in Table 1-12.

Each of the three methods is reasonably well suited for application to the streams found in the Overthrust Belt. PHABSIM permits species-specific analyses but the analysis conducted using HQI and GAWS are generally directed at general or groups of species, e.g. trout. PHABSIM can also be applied in analyses of more than a single-life stage whereas the analyses possible with HQI and GAWS do not permit the same life-stage resolution and examination.

The methods differ also in the accessibility of the documentation. For PHABSIM and HQI documentation is available in both agency reports and the published literature. Documentation for GAWS is available only through agency reports. All three methods are designated for computer analysis but only for HQI are the programs available for use with small programmable calculators. Analysis with PHABSIM and GAWS require larger out-of-office computers.

Both GAWS and PHABSIM are superior to HQI in terms of the applicability to assessments of environmentally sensitive areas, assessments of impacts of development, and mitigation through reservation of definable instream flows.

TABLE 1-12
SUMMARY EVALUATION AND COMPARISON
OF AQUATIC HABITAT EVALUATION PROCEDURES

Evaluation Criterion	PHABSIM	Rating HQI	GAWS
Applicability to the Overthrust Belt streams	High	High	High
Species-specific analysis	High	High	Moderate
Life-stage analysis	High	Low	Low
Availability of documentation	High	High	Moderate
Availability of programs for programmable calculators	NA	Available	NA
Breadth of Application ¹	High	Moderate	High
Availability of different levels of analysis ²	Low	Moderate	High
Utility of end product	Moderate	High	Moderate

¹Breadth of application in terms of the three PCC requirements: identification of environmentally sensitive areas, assessment of impacts of development, and utility in assisting managers develop mitigation programs. A high rating implies full utility here; a moderate rating implies less direct applicability.

²A high availability means that four levels of intensity are available; a moderate availability means that two or three levels are available; a low availability means that only a single level of analysis is available.

GAWS and PHABSIM offer four levels of analysis in terms of the surveys possible with associated field and office methods. HQI offers two or three levels of analysis. The end product of HQI, however, is an estimate of standing crops, which is considered superior to the products of GAWS and PHABSIM, which are estimates of useable habitat area or unitless quality indices.

Evaluation of Effectiveness	PHABSIM	GAWS	HQI
Availability of documentation	High	High	High
Availability of program for computerized analysis	High	High	High
Availability of program for manual analysis	High	High	High
Availability of program for field analysis	High	High	High
Availability of program for office analysis	High	High	High

POPULATION SIMULATION MODELS

INTRODUCTION

Population simulation models are mathematical representations of the primary features of the dynamics of a wildlife population. The functional relationship between population parameters (such as natality and mortality rates) and population size and structure (sex and age) are expressed mathematically and used to simulate population change over time. Most applications of population modeling have involved big game species and have been directed toward evaluation of game management alternatives.

The calculations required in the models can be done by hand or by computer, but most models have been computerized and are normally run on a computer. Computer simulations allow rapid description of long-term population fluctuations and prediction of the effect of changes in population parameters (usually harvest rates).

ONEPOP, POP50, and POSIM are reviewed here. These three models are closely related members of a relatively small family.

ONEPOP

Description. ONEPOP was developed at the Colorado Cooperative Wildlife Research Unit by Jack Gross. Gross recognized that a number of data processing and analysis problems plagued wildlife management (Gross 1973) and ONEPOP was designed to solve some of them. As a simulation model for big game populations, ONEPOP provided a link between existing information on population dynamics and management practices. The model was refined during the early 1970s and subsequently introduced to interested state wildlife agencies through a series of workshops.

Computations in ONEPOP are recorded for a population by sex and age classes. An estimate of the initial population size is supplied according to the established structure. The modeling follows a simulation year which is defined to start at the midpoint of the reproductive season, at which time the model adds all births to the population. During the remainder of the simulation year, which may be divided into as many as 12 mortality periods of varying length, population size is updated from one period to the next by modifying age and sex class numbers according to prescribed natural mortality, harvest, and wounding loss rates.

Reproduction may be entered to the model in one of three ways: as the number of young to be added to the population, as a rate of young per 100 females in the age classes that reproduce, or as a density-dependent rate. If the last option is selected, a linear function is used to relate reproductive success to population size, either through pregnancy and ovulation or in terms of young produced per female. The choice depends on the data available.

Losses from a modeled population are due to natural mortality, harvest, or wounding loss. Outside of the hunting season, all losses are accredited to natural mortality, which is specified as a decimal fraction for each sex and age class in each mortality period. In a multi-year simulation, up to three sets of these natural mortality rates may be specified, allowing mortality to vary between years. Throughout a mortality period, losses are assumed to occur at a constant rate.

During the hunting season, all losses are accredited to harvest and wounding loss. The harvest rates may be both age and sex-specific and, like natural mortality, harvest losses are assumed constant through the harvest period. A sex-specific wounding loss rate is entered as a decimal fraction of the number of animals harvested. Wounding losses are removed at the end of the harvest period and are distributed across age classes in the same proportions as specified in the harvest.

Supplementary calculations possible with ONEPOP are:

1. the trophy and dollar value of the harvest;
2. annual energy consumption and animal-unit months of grazing; and
3. refuge benefit units (i.e. value assessed to wildlife refuge due to species presence).

Output from a simulation using ONEPOP consists of summary information in tabled form. Output includes (Roelle and Bartholow 1976):

1. age and sex class sizes at the start of each year;
2. population sizes at the start of each year, at the time of preseason and postseason composition counts, and at the end of each year;
3. numbers of males (or antlered animals) and females (or antlerless animals) harvested from each age class;
4. summaries of total number or percentages of animals harvested in each year;
5. sex ratios in each age class at the start of the harvest;
6. preseason and postseason management information, including age and sex ratios; and
7. summary information concerning energy consumption, animal-unit months, and refuge benefit units.

Much of the information can be plotted if the user supplies a plotter routine.

Evaluation. Program ONEPOP was written in Fortran IV and can be implemented on most large computing systems. It was developed to operate in batch-mode on a large, centrally-based computer system and is not copyrighted. Operational costs depend entirely on the computer system and method of access. However, because of its basic dependence on batch operation with a large computer, operational costs can be high (Pojar and Strickland 1979). These two problems (cost and dependency on a large centrally located computer) have prompted some users to develop programs that are easier to use and can be implemented on microcomputers (Nellis, personal communication; Pojar, personal communication; Strickland, personal communication).

Much of the present population modeling by management agencies was inspired by ONEPOP. A number of states use the model, including Wyoming, Idaho, Colorado, California and Tennessee. The Colorado Division of Wildlife and the Wyoming Game and Fish Department have used the models quite extensively. The Colorado Division of Wildlife models mule deer, elk, pronghorn antelope, and bighorn sheep populations, and the Wyoming Game and Fish Department models these five species plus white-tailed deer and moose (Pojar and Strickland 1979). The Idaho Fish and Game Department developed trial models for mule deer, elk, and pronghorn antelope, but development has been very slow (Nellis, personal communication).

ONEPOP is accepted as a useful game management tool. Benefits accredited to the model include (Pojar and Strickland 1979):

1. field personnel have recognized the need for a greater emphasis on demographic data on big game species;
2. field personnel were forced to critically evaluate the reliability of available data;
3. models more clearly illustrated the contribution that any particular population parameter estimate makes to the dynamics of a population;
4. modeling encourages all management personnel to consider big game in terms of biologically based units (herd units) and not administratively determined management areas; and
5. models provide guidance for administration regarding where emphasis should be placed in future data-gathering programs.

POP50

Description. The POP50 program (Bartholow 1981) was developed privately by John Bartholow (presently with WELUT) and is basically a streamlined version of ONEPOP. A number of seldom-used features of ONEPOP such as trophy and dollar values for the harvest, energy consumption values, and refuge benefit units have been eliminated. The major change has been the mode of operation; from batch operation on a large computer system with ONEPOP, to inter-

active processing on a Tektronix microcomputer with POP50. The initial investment is higher when operating on a microcomputer, but day-to-day operational costs (with the exception of manpower) and many service-related problems are eliminated. Interactive processing provides a much faster turn-around time, and allows immediate interplay (i.e. "gaming") with the program, thus enabling a user to experiment with harvest strategies or to study the sensitivity of simulation results to various input parameters.

The logic and structure of POP50 are similar to those of ONEPOP but a number of differences were made because POP50 is designed to run on a smaller computer. Only three mortality periods (pre-harvest natural mortality, harvest, and post-harvest natural mortality) exist in POP50, whereas ONEPOP allows up to 12 periods. Mortality rates in POP50 are specified for each of three population segments (young, adult males, and adult females) and cannot vary within these segments although rates from year to year can vary. No harvest rates are used in POP50, and harvest must be specified as numbers removed from the population or as numbers to remain in the population. Unlike ONEPOP, POP50 does not allow density-dependent reproduction or specification of reproduction as number of animals to add to the population. A single reproductive rate is applied to all age classes specified as pregnant and young are divided among the sexes according to a proportion supplied by the user.

Two significant new features provided by POP50 are a Mortality Severity Index (MSI) and the capability to produce presentation-quality graphics. The MSI uses a scale from 0 to 100 and is used to adjust annual post-harvest mortality based upon the relative favorability of winter conditions for survival. The MSI is fashioned after a mortality modifier added to ONEPOP by the US Forest Service in California (Pojar and Strickland 1979). In a given year, the index operates by dividing adult post-harvest mortality for adults by a factor $[(100 - \text{MSI}) \div 100]$ and dividing sub-adult post-harvest mortality by the square of the factor. The MSI has considerably greater influence on the population of sub-adults. Justification for this form of the relation is based on empirical evidence (Pojar and Strickland 1979).

Because POP50 was designed for application on a specific computer, it was possible to incorporate a graphics routine within the program. Output is available in table or graph form for (Bartholow 1981):

1. population size;
2. pre-season natural mortality statistics;
3. harvest mortality statistics;
4. harvest percentages;
5. post-season natural mortality statistics;
6. pre- and post-season ratios; and
7. reproductive statistics;

Composite output can be tabulated or graphed to the user's specifications with additional computer programming.

Evaluation. Bartholow developed POP50 to overcome operational difficulties with ONEPOP, with which he was familiar by virtue of work to validate ONEPOP it as part of his graduate research at Colorado State University (Bartholow 1977). POP50 was designed to avoid the problems of potentially poor computer service and to simplify the execution and reduce the costs of running the model.

As mentioned previously, operational costs for POP50 consist of initial investment for hardware and software. A Tektronix model 4051, 4052 or 4054 microcomputer with at least 32K bytes of memory and an internal magnetic tape unit is a minimum hardware requirement. A printer and plotter are practical options. The program itself is copyrighted and marketed by John Bartholow at a current price of \$1,000.00.

The POP50 program has been purchased by state agencies in Wyoming, Colorado, California, and Missouri. The Colorado Division of Wildlife makes limited use of the model but may expand use in the near future (Pojar, personal communication). The Wyoming Game and Fish Department has used POP50 extensively to model mule deer, elk, and pronghorn antelope herds, and has sponsored efforts to incorporate a new option which will provide a means of evaluating the effects of environmental change on population dynamics (Bajusz, personal communication). The option is based on the assumption that carrying capacity is determined by some limiting factor in the environment. Changes in the limiting factor are related to reproduction or survival rates through a multiplication factor, which is a function of the existing amount of the limiting factor relative to the size of the population and requirements for the limiting factor per individual. The actual functional form of the relationship was initially developed to represent bacterial growth (Williams 1980). The validity and usefulness of this concept in modeling big game population models remains to be tested, but the need for an objective link between population models and the environment is apparent. Such a link would greatly improve the usefulness of population models, particularly in impact assessment and mitigation.

POSIM

Description. The Montana Department of Fish and Game first took a serious interest in population modeling in 1975. Meetings with Jack Gross at the Colorado Cooperative Wildlife Research Unit regarding ONEPOP led to acceptance of modeling in principle, but dissatisfaction remained over the method and form of data entry. A programming firm was consulted to modify ONEPOP to meet the specific requirements of the Fish and Game Department. The firm advised that developing a new program would be easier than modifying ONEPOP. The first document on the resulting program, POSIM (Population Simulation), was published in 1978 (Mooney and Lonner 1978).

Because the Department of Fish and Game is responsible for managing a wide variety of species, management needs provided the primary incentive for developing a population model. Two objectives in the development of POSIM were to be able to forecast animal numbers for different management (harvest) strategies and to provide a means of testing hypotheses related to population growth. POSIM is used primarily to compare alternative harvest strategies.

The primary feature of POSIM is an accounting system which keeps track of the size and structure of a modeled population. The population structure is represented by sex and a variable number of age classes. Counters are used for the number of animals of each age within a sex-age class group. Within this structural framework, the program records changes in numbers due to various population mechanisms: aging, births, natural mortality, and harvest (legal and illegal).

Time is based on the "biological year" in the simulation program (Mooney and Lonner 1978). Modeled species bear young only once a year, and this event determines the start of the biological year. Births may be specified with single birthrates (by female age class) or with conception rates and fetal mortalities. POSIM adds births to the population instantaneously at the start of the biological year, and advances the age of animals already in the population. Time through the year is measured in one-month periods.

The program allows the user to specify a variable number of mortality periods, so that mortality rates can change through the year. Up to 12 periods for natural mortality and five hunting seasons are permitted. Population decline will be constant through a mortality period (although it may change from period to period) unless the user specifies a functional relationship to calculate instantaneous rates.

An additional feature of POSIM is that it allows density dependence and environmental factors to be considered in calculating mortality. A regression equation can be used to scale mortality rates based on population size for a density-dependent relationship. Annual environmental factors such as weather, forage, predation or human encroachment can be incorporated into the mortality equation by applying a subjective favorability or unfavorability index. The index runs from 0 to 10 (10 indicates the most favorable conditions) and is used to modify mortality in each period.

Program input requirements have been designed to allow for numerous options. The program first requires general information such as the length of the desired simulation, the age-class structure, and input-output specifics. Population estimates must be provided for the initial sex and age structure of the population. Standard input will include harvest rates, natural mortality, and birth rates, which may be entered by sex and age class. These rates will often be based on field data, but may be more or less subjectively estimated. In either case, the simulation may help to refine initial estimates. The model can (optionally) be made more complicated with the addition of functional mortality rate equations, density dependent mortality rates, an index relating mortality rates to environmental factors, conception rates and fetal mortality, and/or illegal harvest rates.

The output products of a POSIM simulation are primarily summary tables and plots. Pre- and post-hunting population summaries may be obtained as can monthly or yearly population and mortality summaries. POSIM provides optional statistical information including correlation coefficients for the relation between simulated and field estimates.

The POSIM program was written using a modified version of the GASP IV simulation language (Pritsker 1974). Program operation is conducted in an interactive mode, allowing immediate interplay between the user and the model, a considerable advantage when experimenting with alternate harvest strategies or when trying to refine parameter estimates (Mooney and Lonner 1978). The Montana Department of Fish and Game operates POSIM on the Xerox Sigma 7 computer at Montana State University. Approximate cost figures for POSIM (Lonner 1979) are \$14,000 for its initial development and \$1.50 for an average run at Montana State University. Conversion to another system with the simulation language GASP IV should be reasonably inexpensive.

Evaluation. While not being used to its full potential, POSIM has been used by the Montana Department of Fish and Game to model select deer and elk herds (Lonner personal communication).

SUMMARY EVALUATION OF POPULATION SIMULATION MODELS

Population prediction models are unique in that evaluation of an area undergoing development is often best understood through measurement of impact on the animal carrying capacity. Unfortunately, the existing general population prediction models were not designed to provide objective impact assessment capabilities or mitigation procedures. Objectives typically revolve around evaluation of various harvest strategies for game species. All models that can be applied to more than one species require the user to provide estimates of reproductive rates, mortality rates, and initial population sizes in the various age and sex classes of a population. These models have the capacity for the user to subjectively change the reproductive and mortality rates. Hence, in the case of a detrimental impact, the mortality rates can be subjectively increased (or reproductive rates decreased) to evaluate the resulting effect on the population size and age structure (Strickland, personal communication). However, researchers have been unsuccessful in providing multiple-species population simulation models with functional relationships between habitat parameters and population parameters. One untested exception is work sponsored by the Wyoming Game and Fish Department (Bajusz 1982). They have attempted to incorporate a new option in their population modeling where a functional relationship is specified between reproductive or mortality rates and the amount of critical habitat available per animal. Generally, the models suffer from the inherent complexity of the population dynamics of any species and inadequate data on how environmental variation affects natality, mortality, and other population parameters.

Summary evaluations and comparisons of the three population simulation models are provided in Table 1-13. All three models can be used to model the population dynamics of species with a single annual birth pulse. ONEPOP and

TABLE 1-13
SUMMARY EVALUATION AND COMPARISON OF
POPULATION SIMULATION MODELS

	ONEPOP	POP50	POSIM
Applicability to the Overthrust Belt	High	High	Moderate
Sensitivity for identification of environmentally sensitive areas	Low	Low	Low
Sensitivity for impact prediction	Low	Low	Low
Field testing and evaluation in impact assessment	None	None	None
Potential for evaluation of reclamation and mitigation practices	Low	Low	Low
History of successful applications in impact assessment	Poor	Poor	Unknown
Dependence on subjective judgment	High	High	High
Accessibility of the model	High	Moderate	Low
Time and manpower requirements	Moderate	Moderate	High
Committment to continued development	Low	Moderate	Low

POP50 would apply well to the Overthrust Belt but none of the three methods would have any utility in identifying environmentally sensitive areas, assessing impacts, or developing mitigation programs because they were not designed for these purposes. ONEPOP and POP50 have poor histories of successful application in impact assessments and POSIM's history is unknown. ONEPOP is the most accessible of the three models. POSIM is the most demanding in terms of time and manpower requirements.

For unique species and habitats, attempts have been made to develop population simulation models which can be used to link "impact" to animal numbers and minimum habitat requirements (e.g., Shaffer 1978, Cooperrider and Behrend 1980, Stromberg et al. 1982). Similar applications to single species or small groups of similar species should be possible in the study area.

COMBINATIONS OF PROCEDURES

INTRODUCTION

Each of the procedures reviewed above has potential utility at one or more points in the planning process somewhere between initial collaborative analysis and monitoring and project reevaluation. However, by virtue of their common reliance upon mapped information, their existing or potential use of the computer, or their products, these methods can be used not only independently or sequentially, as they are or might be now, but in a more dependent, integrated way.

This section offers examples of how the procedures reviewed (or similar procedures) have been or are being used in conjunction and, where possible, suggests ways in which they could be made functionally compatible. Descriptions of existing combinations (as well as suggestions as to which might be developed in the future) have been developed by reviewing the literature and contacting those individuals who have forged the combinations or who have made attempts to establish them. Suggestions for other potential combinations are based on the familiarity with the procedures gained through the review.

EXAMPLE COMBINATIONS

AEAM, geographic information system capabilities, and FWS's Habitat Evaluation Procedures are being used in Nebraska on resource problems involving the Platte River. The Platte River Whooping Crane Habitat Maintenance Trust (referred to hereafter as the Trust, or PRT) was formed as a private corporation whose membership included prior employees of Basin Electric, the State of Nebraska, and the Wildlife Federation. The PRT's mandate is to protect the habitat in an 80-mile-long, sevenmile-wide area centered on the Platte River.

Some time after the PRT began to assume its responsibilities, the Nebraska Natural Resources Commission (NNRC) set up the Platte River Forum for the Future (PRFFF) and began to use AEAM to decide how best to use the remaining, unclaimed Platte River water. One of the primary stimuli was the large number of diversion and allocation requests made following the 1980 Supreme Court decision that transbasin diversions were legal. The products of the AEAM process were to be: a computer model of the Platte River basin, a set of new options for using the Platte River, a consensus on how Platte River water could best be used, and a team of Nebraskans trained in using the Platte River computer model and in conducting workshops.

The AEA Group at WELUT began the process after entering into a contract in June of 1982. The organizational framework has been set up as the Platte River Forum For the Future (PRFFF). The first scoping meeting has been held and the workshop participants were identified. Bounds were placed on the problem and the first computer simulation model was developed. The participants include three state senators from Nebraska, Director of the Water Resources Department, representatives of the Governor's office, Sierra Club,

PRT, FWS, Bureau of Reclamation, Wildlife Management Institute, and stock grower's and irrigator's associations.

The Platte River model and the AEAM process are intended to show the costs and benefits of various alternatives posed by the organization represented. The model will have submodels that will estimate the effects of different alternatives on tax structures and rates, corn production, nitrate content in groundwater within the basin, and the amount of wildlife habitat available along the Platte River. However, as a predictive tool, the model is rather general and it will be used primarily to set policy.

The PRT recommended AEAM to the NNRC, participates heavily in the process and has, in fact, played a very large role in funding it to insure its continued success. The PRT initially provided \$25,000 of the contract amount of \$220,000. However, participation in the PRFFF does not fulfill the PRT's responsibility for three reasons. First, the AEAM process and the PRFFF work at a general policy level and, as perceived by John VanderWalker (personal communication), are not really intended for use as analytical tools. Second, the AEAM process requires compromises which fall outside the Trust declaration and the PRT members' responsibilities. Third, the management and protection of wildlife habitat along the 80-mile stretch of the Platte River require more detailed information than the Platte River model will contain or produce and the use of other tools is necessary.

To meet its needs the PRT has taken the initial steps to use a geographic information system and HEP in combination. Habitat suitability models will be developed for each of several bird species. Because the greatest amount of information is available for the sandhill crane, work on that species model was begun first. Variables included in the HSI models were selected based on the following assumptions (research-based or from expert consensus) regarding sandhill crane needs: 1) the birds prefer to roost in water that is not deeper than the first joint in the leg; 2) they prefer between 75 and 150 meters of clear unobstructed view of their surroundings when on their roosts; 3) they require both agricultural and wetland areas as feeding areas; 4) they are disturbed by a number of man-made features and human activities, including roads, railroads, and the passage of trains; and 5) disturbances can be much closer to feeding areas than to roosting areas (VanderWalker, personal communication; Schamberger, personal communication). This list is not complete and is intended only to indicate habitat requirements that are amenable to the kinds of spatial and proximity analyses that are possible using a computerized information system.

The WELUT RAM Group has provided most of the services to date in the area of information system needs. It wrote the specifications for 1:24,000-scale color infrared aerial photography, had the photographs taken, and did the photointerpretation using a habitat classification system agreed upon by the PRT and several selected experts. WELUT also created the spatial data base upon which the initial habitat analyses will be based (Asherin, personal communication). The data base has been constructed by mapping and digitizing polygons

and converting the map of polygons to a map of cells. MOSS, including the Yale University MAP software, will be used in the analyses.

The PRT sees four major uses of the combined GIS-HEP procedure (Vander-Walker, personal communication). First, the cells will be evaluated in terms of the properties included in the HSI models and, based on the weighted values of the cells as habitat, larger areas will be assessed in terms of the potential value to the sandhill crane and other species. Second, areas found wanting for one or another reason but which could be converted into quality habitat under management, can be identified and considered for possible purchase by the PRT. For example, an area where vegetation has encroached into the channel and has reduced unobstructed visibility to less than 75 meters could be evaluated in terms of its value if flow could be increased to eliminate emergent species. A host of hypothetical "what if" games can be played to determine what combination of purchase and management of vegetation and instream flows could produce the greatest gain in habitat at a given cost (or an equal gain at the least cost). Fourth, the PRT will be able to use its GIS/HEP-based information to make strongly supported suggestions to the PRFFF for alternative uses which best enable them to meet their objective of preserving 80 miles of habitat. The GIS provides accurate and effectively displayed spatial information, the HEP procedure is well-documented, and the assumptions underlying the PRT arguments will be clearly outlined in a "paper trail". Fifth, the PRT will be able to precisely analyze the effects of alternatives developed and tested by the PRFFF participants in AEAM workshops. The PRT is in the process of developing detailed hydrologic models which, in conjunction with the spatial data base and the HSI models, will provide the tools necessary to check the results of the simulations of the more general computer model developed in the AEAM process. The greater analytic and predictive powers of these combined tools will put the PRT in a good position to defend challenges to their position.

AEAM, RAM, and HEP are being used on the same type of problems on the Platte River, but not to the same end. RAM and HEP will be used more as a check by one special-interest organization on the outcome of efforts made by a broader-based organization using AEAM. As a result, they are not receiving truly joint use. However, joint use would be conceivable if the more detailed data base and habitat evaluation procedures were being used by the PRFFF. The same checking process is possible within an organization.

Another possible combination of different procedures is the use of an information system in conjunction with simulation models. Such combinations have been devised to determine the impacts of development and/or management alternatives. Schreuder et al., (1976) described a simulation system developed to assist in the evaluation of physical, economic, and environmental impacts of land use planning decisions in the Snohomish River Valley in the state of Washington. Computer simulation models were linked with a computerized cell-based geographic data base and simulation runs with the model were used to predict how that data base would change in response to certain actions. This system (SVEN) has the capability to take original cell maps, run the simulation models to determine how the conditions in each cell would

change, and then update each cell to produce entirely new maps. The new maps indicate how the mapped area as a whole would change in response to the actions that were used to drive the simulation models.

The SVEN system is primarily used as a forest management tool because of the abundance of forested land in the Snohomish Valley. Several simulation models can be used in sequence to predict the economic and environmental effects of an array of forest management decisions. For example, the timber harvest model can use information on the forest type (which varies throughout the Valley), determine for each cell on the map what harvesting method should be used, and change the original type attributes for the cells (some average basal area, height, and number of trees) to new post-harvest attributes. After applying the harvest model the user can apply a forest residue model to determine what kind of residue would be present in each cell given the original timber type and the harvest method. The forest residue model operates on the entire map, cell by cell, to determine what the undiscounted residue treatment and salvage operation costs (if any) would be, what the dollar returns would be, and what amounts of solid and gaseous pollutants would be released to the atmosphere.

The SVEN system has two other models that can be used at this point to continue the analysis of impacts. These are the meteorological and atmospheric models. Pollutant information produced by applying the forest residue model can be coupled with climatological information developed by the meteorological model to simulate the percent number of days when the pollutant level in the basin would exceed established threshold air-quality standards. The model, therefore, can be used to predict how forest harvesting schemes would affect air quality and how air quality standards restrict forest harvesting and residue treatment practices.

This system of computer simulation models and data bases shows how simulation modeling can be used in conjunction with GIS and DBMS technology to consider the impacts of management alternatives. Such extensive analyses are not usually possible manually. Furthermore, automatic procedures for updating geographic data bases eliminate the extremely costly and time-consuming drafting requirements.

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AVAILABLE LITERATURE ON THE EFFECTS OF DEVELOPMENT ON WILDLIFE RESOURCES

INTRODUCTION AND SUMMARY

The Task 2 Literature Review presents information found in available literature on fish and wildlife impacts resulting from natural resource development and human activities. While the primary focus of the review was to examine documented relationships between petroleum industry development and wildlife, reported influences of road construction and use, mining, logging, aircraft, transmission lines and other structures, grazing, fire, and recreational use in wildlife habitats were included. These activities have similarities to aspects of oil and gas developments and known effects on fish and wildlife provide valuable information. The literature review is divided into sections which discuss information about a group of related species: big game, furbearers, raptors, game birds, nongame wildlife, amphibians and reptiles, fish (and aquatic resources), and threatened and endangered species. A section on psychological stress, in the context of human disturbance, is included in the review.

In Task 2, a number of computer data systems were searched as outlined in the methods section. General review papers which discussed the impact of habitat changes on wildlife were sought. Papers which examined the possible effects of oil and gas development on wildlife or which reported on work conducted in the Overthrust Belt, particularly the Bear River Divide, were evaluated. Papers on particular wildlife and habitat groups were reviewed by experts in those areas. Their approach was to assess general review articles, papers that documented the possible effects of oil and gas development, and specific papers that apply to the Overthrust Belt. Factors considered included whether conclusions and management recommendations were based upon field experimental data of sufficient depth and breadth, soundness of field and analytic techniques, experimental design, and applicable theoretical considerations involving testable hypotheses and alternatives.

In searching the literature we assumed that evaluation of impacts on wildlife required knowledge of wildlife species prior to development. This knowledge should include wildlife present, their requisite needs including environmental and biological. During the literature search we found very little data on wildlife in the Overthrust Belt prior to the beginning of oil and gas exploration.

In the absence of such data we searched for data collected during the process of development. We assumed that information should be available on the species present, unique features of the region that affected each species and species response to different forms of disturbance. The reviewers felt that data on unique species as well as species of high public interest were particularly important. As a result, data gaps were identified when these types of data were lacking for groups of wildlife in the Overthrust Belt. Data gaps were translated into proposed projects in Task 6, the report for which has been submitted separately.

The major conclusions from the review are:

1. there is little information on wildlife species and the possible impact of oil and gas development on wildlife in the Overthrust Belt. Thus, a major recommendation is that population and habitat surveys be conducted for each group of animals. Surveys of habitat availability, quality, and unique habitat features for wildlife species are also recommended.
2. habitat requirements of various fish and wildlife species change during the annual cycle. Changes in wildlife distributions vary over time due to particular resource requirements. Thus, certain species may be confronted with human disturbances or may be particularly sensitive to disturbances during one time and relatively tolerant at another time. Recommendations include identification of target species to serve as the basis for impact assessment with determination of spatial and temporal distribution studies on these species.
3. the importance of riparian and aquatic habitats in the arid west is emphasized for many wildlife groups. Oil and gas developments have the potential to adversely affect big game, game birds, furbearers, herpetofauna, fish, raptors, and nongame wildlife through disturbances in riparian areas, oil spills, mud pit contaminants, sedimentation of surface water and contamination of ground water. Monitoring water quality in relation to wildlife use of riparian and aquatic is proposed.
4. the literature review shows that little research has been done specifically on the impacts of the oil and gas industry on fish and wildlife species occurring in the Overthrust Belt when compared to other forms of developments or environmental alterations. However, available literature suggests that many aspects of oil and gas development are not unique forms of human impact on wildlife. Habitat alteration and human disturbance to wildlife during oil and gas development occur in much the same manner as other forms of development. Information gained from impact research on logging, grazing, fire, mining and other forms of habitat alteration is useful. However, habitat used by impacted wildlife populations and population response to habitat improvements are poorly understood. Knowledge of these relationships is essential if effective mitigation and reclamation in wildlife habitats are to be realized.

Task 2 Organization

The literature review is presented in sections by major wildlife group: big game, furbearers, raptors, game birds, nongame wildlife, amphibians and reptiles, fish (and aquatic resources), and threatened and endangered species. A section on stress responses of wildlife to disturbances is also included. Each section has been organized into several subsections including an intro-

duction, literature overview, effects of resource development, summary of available data regarding the wildlife group, and summary of data gaps. The review of resource development focuses on the specific effects of exploration and development of oil and gas (geophysical or seismic exploration, road and pipeline construction, drilling rig operation, oil and gas field development). Literature dealing with other activities, such as road use, mining, logging, grazing, recreation, and human disturbances, are included in appropriate subsections. Studies of general applicability to the Overthrust Belt are included in a separate subsection which summarizes literature on habitat affinity, critical resources, and relevant life history phenomena that can be used to identify information needs on a specific wildlife group. Each section concludes with a summary of what the literature indicates and a definition of data gaps that identify where future endeavors can provide a more basic understanding of wildlife/disturbance relationships.

Overview of Effects

The effects of resource development on wildlife can proceed in two ways. First, the impact source can affect animals directly to cause escape, avoidance, displacement, disruption of reproduction or maintenance activities, or in extreme conditions, mortality. Chronic psychological stress produced by impact sources may lead to decreased survival and reproduction although this is unproven. Alternatively, human disturbances can alter wildlife habitat rendering it unsuitable or unavailable for animal use. Habitat loss and alteration can lead to decreased wildlife habitat carrying capacity resulting in smaller populations and less animal species diversity. Direct effects of impact sources are more obvious and easier to document than population responses to changes in habitat quantity and quality. Impacts having direct effect on wildlife may be difficult to distinguish from impacts affecting habitat which in turn affects wildlife. In addition, yearly and seasonal variations in environmental conditions are known to influence behavior, distribution, and reproduction of many wildlife species. Consequently, research directed at impact assessment must be carefully designed so that cause and effect relationships can be discerned and the influence of environmental variation taken into account.

Literature on the effects of oil and gas development on wildlife is not extensive. Several papers were reviewed which documented displacement of big game by seismic exploration activities. Big game displacement away from oil and gas drilling was also examined by several investigators but the results from these studies were not consistent nor always conclusive. In some instances, big game did avoid the drilling operations but in others, there was no apparent displacement. Too, displacement seemed to be a short term phenomenon. There appears to be differential responsiveness between big game species and of the same species at different times of year. Prior experience with hunters also influences big game response to human disturbances.

Big game species also vary in their responsiveness to road and air access according to the literature. This appears to be related to past hunting pressure but there are species differences in degree of sensitivity.

Differences of game bird species' response to road and air traffic have also been reported. Sensitivity is heightened during nesting. Generally, wildlife sensitivity to human disturbances is greatest during the reproductive period where these interactions have been investigated: nongame birds, raptors, and waterfowl may abandon nest sites; grouse may curtail breeding activities on leks; elk may shift their calving areas; bears may leave dens. Likewise, power poles also serve as hunting perches for raptors.

Poaching and increased local harvest are probably the most significant documented impacts of increased human access to wildlife habitat. Susceptibility of native cutthroat trout to fishing pressure has been noted by several investigators. Increased harvest of moose has been associated with proliferating roads and has been a concern of elk habitat. Poaching of mule deer and white-tailed deer is suggested by some to increase in the vicinity of strip mines and crew camps. However, no quantitative studies have related changes in wildlife population densities associated with increased human access and illegal hunting. Road-related mortalities have also been a concern, particularly for some big game species, scavengers such as the bald eagle, small mammals, and reptiles. Again, the effect of these mortalities are unknown.

Aside from mortalities associated with roads and vehicular traffic, new structures, especially transmission lines, can cause wildlife mortality. Raptors perching on utility poles are particularly vulnerable to electrocution. Other birds, including game and nongame species, have been documented to collide with powerlines and communication towers. The problem is heightened during migration periods and during times of poor visibility.

According to available data, aquatic and semi-aquatic wildlife are particularly vulnerable to direct impacts caused by oil-spills and contamination of surface water. Organic and inorganic components of mud pits and drilling fluids are toxic to fish. The extent, if any, of these contaminants in aquatic habitats and aquifers is unknown. Atmospheric emissions of sulfur dioxide from sour gas treatment facilities has been hypothesized to acidify surface waters but is undocumented. The relatively high buffering capacity of water in the Overthrust Belt may prevent acidification from being a serious local problem. However, the effects of oil spills on waterfowl and aquatic fur-bearing mammals is a potential source of mortality. And, entrapment of waterfowl, nongame wildlife, and herpetofauna in containment ponds associated with the petroleum industry has occurred in areas of oil and gas development.

Habitat alteration and its effects on wildlife is reported primarily for fish. Removal of terrestrial vegetation, whether from road and drill pad construction, logging, grazing, or off-road vehicle use, can lead to soil erosion and sedimentation in streams and ponds. Increased sediment loads can cause water temperatures to increase and dissolved oxygen to decrease. Many fish species in the Overthrust Belt are intolerant to high water temperatures and sedimentation may decrease available spawning habitat.

Vegetation removal is indicated by the available literature to affect population and species diversity of nongame birds and mammals. In some cases,

such as tree removal in forested areas, species diversity of birds may increase due to growth of secondary succession vegetation and increased habitat diversity. Some big game species may also benefit from increased habitat diversity. In other cases, where native vegetation has been removed and replaced by monocultures of introduced plants, small mammals species diversity declined and only one or two species persisted. Clearly, habitat diversity is of prime importance to the maintenance of nongame wildlife diversity. This may also have ramifications to predator species of raptors and terrestrial furbearers. Table 2-1 summarizes documented and potential influences of disturbance sources on wildlife.

According to available data, habitat modifications can be beneficial to wildlife. Creation of artificial nesting structures has been successful for increasing nesting habitat for raptors and waterfowl. Artificial nesting structures have also been used to mitigate the effects of human disturbance. Efforts to relocate traditional sage grouse breeding grounds have had mixed success. Habitat manipulation, whether by vegetation removal or enhancement by fertilization is indicated to increase use by big game and nongame wildlife. Literature reporting the success of these improvements does not, however, include information describing population changes and the studies were often conducted on unaffected areas. Thus, while habitat manipulation and improvement techniques are known, the use of these to ameliorate habitat losses is not reported.

In summary, the literature review provides numerous reports on the effects of human disturbance on fish and wildlife. The disturbances may affect animals directly through mortality, behavior, or changes in reproduction, or may affect animals indirectly through altering wildlife habitats. In some cases, cause-and-effect relationships are well known. But often, the reported wildlife response to an impact source is not clearly defined because of effects compounded by environmental conditions and poor study designs. Well-defined cause-and-effect relationships between impact sources, habitat manipulations, and wildlife population responses should be determined.

Literature of Particular Interest to Oil and Gas Development

Several review papers are cited in the following sections. Some of these papers apply to oil and gas development and others apply to different forms of habitat disturbance.

Thomas et al. (1979) summarize wildlife management criteria in general, although this publication does not directly relate the Overthrust Belt. It provides a valuable introduction to the needs and different habitat characteristics (e.g. riparian zones, edge, snags, cliffs and caves) which contribute to wildlife management. The summary, based on data from both field studies and the literature, presents a reasonable facsimile of the way managed forests and wildlife interact.

Several review papers relating industry developments to wildlife impacts were examined. Baker et al. (1980) provided a general approach to dealing

TABLE 2-1. IMPACTS EXPECTED FROM DISTURBANCES TO WILDLIFE GROUPS
IN THE OVERTHRUST BELT ACCORDING TO AVAILABLE DATA

	Vegetation Removal	Recreational Access	Vehicles	Aircraft	Noise	Fence and Transmission Lines	Pits and Fluids	Oil Spills
Big Game	↓Habitat *Displacement	*Displacement *Poaching ↑Harvest	*Displacement *Road Mortality	*Escape	*Displacement	↓Movements		
Furbearers	↓Habitat ↓Prey Species ↓Water Quality	?Displacement *Poaching ↑Harvest	?Road Mortality		?Displacement		?Water Quality	↓Water Quality *Mortality
Raptors	↓Prey Species	?Displacement ?Poaching	?Road Mortality	*Escape	*Displacement	?Collisions *Electrocution		
Game Birds	↓Habitat	?Poaching ↑Harvest	*Displacement ?Road Mortality	*Escape	*Displacement	*Collisions	?Water Quality *Entrapment	↓Water Quality *Mortality
Nongame Wildlife	↓Habitat		*Road Mortality			*Collisions	?Water Quality *Entrapment	↓Water Quality *Mortality
Amphibians/ Reptiles	↓Habitat ↓Water Quality	?Mortality	*Road Mortality				?Water Quality *Entrapment	↓Water Quality ?Mortality
Fish and Aquatic Resources	↓Water Quality	↓Water Quality ↑Harvest					?Water Quality *Entrapment	↓Water Quality ?Mortality
Threatened- Endangered Species	↓Habitat	?Displacement ?Poaching	?Road Mortality	*Escape	?Displacement	*Collisions *Electro- cution	?Water Quality	↓Water Quality

Key: ↑ indicates increased effect; ↓ indicates decreased effect; ? indicates poorly documented effect; * indicates documented effect.

with energy impacts on big game species in northwestern Colorado. While this paper reviews existing information pertinent to particular species in this geographic area, it discusses problems associated with impact assessment and specific research needs for big game but applicable to other wildlife categories. Listed are information needs on habitat requirements, combinations of habitat components, influence of human occupancy, the value of mitigation procedures, identification of indicator and sensitive species for use in impact assessments, development of field technique for measuring parameters of interest, and relationships of environmental factors to each other. Continuing work in northwest Colorado recently has been accomplished by the Northwest Colorado Wildlife Consortium. This inter-agency group has prepared documents for the Bureau of Land Management reviewing available information on fish and wildlife groups inhabiting this part of Colorado. Reviews of the legal aspects of wildlife management; current regulatory and management agency policies affecting wildlife, land ownership and classification status; vegetation cover; analysis of local reclamation efforts; and wildlife impact assessment procedures have been undertaken by members of the Consortium. Once these documents are available to the public they will provide supplemental and complementary information to this task, as well as Task 1 and Task 5, of the Cooperative Wildlife Program's Phase I. These works focus on the development of the coal and gravel mining and oil shale industries but they provide information applicable to the oil and gas industry.

Two documents dealing specifically with oil and gas development and known or potential impacts on terrestrial wildlife species were valuable to this review. First, Bromley (1982) compiled and annotated 121 citations that either deal specifically with oil and gas development or examine various human disturbances as they apply to the petroleum industry. She summarized component activities associated with each phase of industry development and identified various impacts resulting from roads and traffic, aircraft, noise, human structures, landscape alteration, hunters and recreationists, and the production of harmful substances by the industry. The other study was done for the Canadian Petroleum Association by PRISM (1982). It draws upon extensive literature to provide an overview of the impacts of petroleum industry operations and land use activities on wildlife. It showed 13 major interactions between wildlife and oil and gas activities. Nineteen measures for reducing or avoiding impacts were recommended.

Brink (1978) reviewed the effects of pipeline construction in Alaska on birds and mammals. She used thorough field studies and accepted methods to document habitat change caused by construction activities. The primary emphasis in Brink's studies was the effect of haul roads. Brink (1978) showed that diesel fuel and crude oil were lethal to a number of plant species and that their introduction into the environment changed the food base for wildlife.

Another study showing direct oil and gas development impacts on wildlife in Michigan was done by Bennington et al. (1982). Standard techniques were used to show that oil and gas related construction activities had localized, short-term impacts on elk, bear, and bobcat. Activity on the part of the three species declined within one-quarter mile of active drilling operations,

three species declined within one-quarter mile of active drilling operations, but it increased to pre-drilling levels two to four weeks following construction.

BIG GAME

Introduction

Ten big game species potentially occur in the Overthrust Belt of Wyoming, Idaho, and Utah. Findholdt et al. (1981) document elk, mule deer, moose, pronghorn, big horn sheep, bison, mountain lion, black bear and grizzly bear breeding within the Overthrust Belt in Wyoming. Big game species are the most visible and sought after wildlife and impacts on this group are most noticeable and most discussed (e.g., road kills, change in hunter harvest). Studies dealing with big game response to development focus on elk and mule deer, and to a lesser degree on moose, big horn sheep, pronghorn, grizzly and black bear. Available literature on big game response to oil and gas development is limited and most studies appear as unpublished consultant or agency reports. By contrast, big game relationships to logging activities, as well as road and aircraft disturbances, have been more thoroughly examined. Since many activities associated with oil and gas development are similar to other developments, such as logging, roads and mining, this review includes big game responses to these forms of human disturbance as well as studies documenting habitat affinity and secondary effects associated with increased human use and access.

Literature Overview

Several review documents summarize known relationships of big game species with various human disturbances. Neil et al. (1975) surveyed the effects of off-road vehicles, feral or uncontrolled dogs, and road development on big game and other wildlife. More recently, Bromley (1982) compiled literature specifically dealing with oil and gas impacts on wildlife, including big game. Known effects of disturbance sources such as aircraft, noises, traffic, hunters and recreationists, human structures, alteration of landscapes and release of toxic substances are discussed and cross referenced with specific impact responses by various species. PRISM (1982) provides a review of the effects of oil and gas activities, roads, human access, and other land uses on big game species.

Literature on the effects of oil and gas development on big game focus either on seismographic or well development activities. Relations of big game to seismographic work include studies on elk (Knight 1980, Horejsi 1979, Olson 1981, Hoskins 1981), mule deer (Horejsi 1979, Ihsle 1982), and moose (Horejsi 1979). Available literature dealing with big game response to oil well drilling, operation and oil/gas field activities focus on elk (Knight 1980, Johnson and Lockman 1980, Hiatt and Baker 1981, Bennington et al. 1982, Beak Consultants, Ltd. 1979, Smith and Bloomfield 1980), mule deer (Hiatt and Baker 1981, Ihsle 1982, Beak Consultants, Ltd. 1979), moose (Beak Consultants, Ltd. 1979) black bear (Bennington et al. 1982), and grizzly bears (Harding and Nagy

1980). These studies document big game are displacement from disturbance by using telemetered or marked animals, distributions of unmarked animals, or track counts on areas proximate to and distant from disturbances. In most cases, the studies are plagued by short durations, inadequate sample sizes, and lack of control areas; therefore, they provide inconclusive results.

Studies dealing with the impacts of logging, roads, aircraft, and mining on big game generally extend for longer durations and often employ sound designs facilitating hypothesis testing. These attributes are requisite to account for both the effects of impacts and inherent variation on animal distributions and behavioral or physiological responses to disturbances. The effects of increased human access on big game has been addressed in studies documenting direct mortality due to vehicular collisions, increased hunting and poaching of local populations, and displacement of animals away from access roads or escape from aircraft and vehicles. Big game mortality on roads and highways has been shown to be dependent upon numerous factors including species (Ward et al. 1976 and 1980), periods of migration (Goodwin and Ward 1976, Wallmo et al. 1976, Arnold 1978, Carbaugh et al. 1975), roadside vegetation characteristics (Bellis and Graves 1971, Goodwin and Ward 1976, Carbaugh et al. 1975) and traffic volume (Arnold 1978, Wallmo et al. 1976). Effects of hunting and illegal harvest on big game populations as a result of human population growth and local demands have been addressed by Smith and Bloomfield (1980), Kuhn and Marstens (1979), Biggins (1978), and Bider and Pimlott (1973). While Lynch (1973) and Bergerud et al. (1968) have implicated increased hunting pressure in declining moose populations, unequivocal documentation of the effects of illegal harvest on big game populations remains to be accomplished.

Road construction and other surface disturbances eliminate some big game habitat but the human activity accompanying these developments may increase the loss of habitat if big game animals avoid or are displaced away from the disturbance. Elk displacement from logging activities and logging roads has been reported by Ward (1973), Ward et al. (1972, 1975, and 1976), Schultz and Bailey (1978), Morgantini and Hudson (1979), Hershey and Legee (1976), and Irwin and Peek (1979) as well as others. Big game may also escape from vehicles and humans (Kucera 1976, Richens and Lavigne 1978, Schultz and Bailey 1978, Ward et al. 1972, Ward 1976, MacArthur et al. 1979, Reeve 1982). Aircraft also cause escape behavior in big horn sheep (MacArthur et al. 1982), Pronghorn (Luz and Smith 1976), moose (Lenarz 1974), and grizzly bears (Harding and Nagy 1980). Disturbances such as mines and fence lines may also present barriers to movement to deer (Kvale 1980) and pronghorn (Riddle and Oakley 1973, Mapston 1970, Sundstrom and Hepworth 1968). There is no literature attributing human disturbance to big game population changes as a result of displacement from preferred or critical habitat and increased stress due to human harassment, intentional or otherwise. Documentation of development impacts on big game survival and production of young will require long term studies which can account for habitat-animal interactions, habitat qualitative and quantitative changes, and the influences of environmental variation on big game populations. Without knowledge of the myriad relationships between animals and their surroundings, the influence of humans will remain obscure.

Studies of the Effects of Resource Development on Big Game

Oil and Gas Industry. Several studies were reviewed which examined relations between seismic exploration and big game species. Perhaps the most relevant study was conducted in Michigan by Knight (1980), who monitored 13 radio-collared and 16 neckbanded elk for two to three days before and up to 10 days after seismic activities in which dynamite was exploded underground. Habitat types in the area included aspen and upland hardwoods with 9 percent open areas. Most feeding by elk occurred under heavy forest cover, which is not the usual case in the Overthrust Belt. Knight examined habitat variables to test the hypothesis that vegetation types, topography, or escape cover influenced the response by elk. He found no correlations because of the relatively low density of elk and the low variability among habitat types. Elk displaced by seismic activity could find equally suitable habitat a short distance away.

In areas within the Overthrust Belt which have large big game populations, studies indicate that variation in habitat conditions will affect responses to seismic and other oil/gas related activities. Basile and Lonner (1979) and Allen (1977), working on elk in relation to human disturbances and forest roads in Montana, found that responses of elk vary in relation to density and diversity of habitat types. Thus, interactions between elk and seismic activities in the relatively homogeneous forest of Michigan, where forest understory shrubs such as beaked hazel, mountain maple, aspen and bush honeysuckle form the bulk of diets, may not be applicable to the Overthrust Belt, where most big game feeding occurs in patchy environments on grasses and forbs in meadows, riparian zones, mountain grasslands, forest parks and clear-cuts, or mountain shrubs.

Knight (1980) found a three- or four-fold increase in daily movements of elk that were disturbed by seismic activities within 1,000 m. Hoskins (1981), in an observational study on general distributions, found that elk wintering in the Bighorn Basin south of Cody, Wyoming, responded by moving when seismic activity was within five km. In both studies all movements resulting from seismic activity occurred within one day after disturbance. Elk moved back to the area within one week of the displacement. Hoskins, therefore, concluded that no significant changes in home range occurred. In the Michigan study, no significant changes in home ranges occurred. Although displacement was shown, the direct and indirect effects of additional energy expenditures on elk nutritional relationships, energy budgets, or production of young are unknown.

Horejsi (1979) related big game interactions to seismic activities in a critical wintering zone in Alberta's Kakwa River region. In that area seismic lines were cut through the forest, much like electric powerline rights-of-way. Seismic activities were conducted using tracked vehicles, bulldozers, and helicopters. Using track counts and general observations, Horejsi concluded that use of seismic lines by moose was reduced during times of intensive seismic activities (i.e., moose were displaced), but the additional burden to wintering moose was probably limited. However, this work was limited to six

weeks of field effort when snowfall was abnormally low. The study was inconclusive because it was descriptive rather than experimental.

An observation by Horejsi (1979) may be useful in conceptualizing the indirect effects of oil/gas activities on wildlife. He noted that wolves used the seismic lines in Alberta as travel lanes for hunting. It is well known that moose use logging roads and trails in winter for similar purposes. In the Alberta study the moose had no apparent unusual problems with wolves, but they might under deeper snow conditions when high snow-berms on the edges of seismic trails may give the predator an advantage. For the most part, questions relating the impacts of human disturbance with habitat change and alterations of interspecific relationships such as competition and predator/prey interactions have not been addressed.

Olson (1981) monitored four radio-collared elk in relation to seismic activities in an area of Montana that contains habitat similar to that found over much of the Overthrust Belt. However, frequency of radio tracking was too low and no control was designed to test significant hypotheses. The study produced data suggesting that elk were displaced by seismic activities. Data were too limited to test if displacements resulted in changes of habitats selected or if elk spent more time foraging in habitats of lesser quality.

Ihsle (1982) monitored 25 radio-collared and 122 neck-banded mule deer in relation to potential impacts of gas and oil development along the east slope of the Rocky Mountains in north central Montana. Because it was a baseline study on distributions, movements, population conditions and habitat use before significant industrial development, few conclusive results were found. Seismic activities were intensive during the study, and some general relations were observed. Radio-collared deer did not show any apparent, longterm changes in seasonal home ranges resulting from seismic activity. However, relocation flights occurred only twice per month and home ranges were mapped on the basis of 4-7 winter relocations and 7-17 summer relocations per animal. Empirical evidence contained in published literature indicates that 21-25 relocations are minimal to delineate a seasonal home range. Ihsle (1982) did not have a design by which she could adequately test if seismic activities produced changes in habitat use by deer.

There are few studies which quantify interactions between big game and individual drilling rigs or full development of an oil or gas field. Knight's (1980) study in Michigan related movements of elk to a rig on a two-acre drill pad and access road. He observed no significant relations between daily distance moved by elk and the distance from drilling activity at 600 m, 800 m, or 1,000 m. There were no obvious changes in home ranges associated with drilling activity.

Johnson and Lockman (1980) found that elk avoided an active drilling rig by moving away during spring in the Snyder Basin area within the Overthrust Belt in Wyoming. Weaknesses in that study arise from limited pre-disturbance data, no control, and the use of pellet group plots as a technique. In comparing elk distributions between two years, one post-disturbance and one

during disturbance, the timing of snowmelt, plant phenology, and subsequent arrival of elk in high elevations (such as Snyder Basin) is highly variable, influencing cumulative pellet groups. Also, if the animals that were apparently displaced were able to find equally suitable habitat, possibly no effects may occur. There is however, an untested hypothesis that too frequent movements may pre-dispose elk calves to higher mortality due to accidents, subpar nutrition, predators, or diseases (Schlegel 1978). This would appear to be a topic for further study.

Hiatt and Baker (1981) conducted a study in Wyoming that has relevance to the Bear River Divide. They examined relationships of elk and mule deer to a wildcat well drilled on winter range on Crooks Mountain in central Wyoming. They used track counts, time-lapse cameras, and ground and aerial observations before and during the well drilling. Wells had been drilled in the area in the past. The well site was located in sagebrush-bitterbrush habitat over 600 m from timber cover. Track counts indicated the few elk present in the area may have responded by moving three km away after drilling started, but their distributions were not negatively influenced by traffic along the access road.

The Crooks Mountain study was not conclusive because of poor conditions for counting tracks following the initiation of drilling and the low numbers of elk present. In addition, the eight days of pretreatment data and the fact that big game moved away from winter range earlier than usual limit the utility of the data. The time-lapse cameras were ineffective, possibly because the animals may have been somewhat nocturnal in their habitat use patterns.

Another study relating an oil rig to wintering big game was conducted in Alberta by Beak Consultants, Ltd. (1980). They used track surveys in the vicinity of an active oil rig located in heavy white spruce and lodgepole forest. They also observed big game use in a river valley bottom, the nearest preferred habitat. Elk became accustomed to operations and noises associated with the drilling rig, and used winter habitats in close proximity. This field study lasted only from December 1978 to March 1979, and no pre-disturbance data were available. Some animals may become accustomed but critics could argue that many others were permanently displaced.

Bennington et al. (1982) used track counts to document displacement of elk, black bear, and bobcat away from a drill site in lower Michigan. They found no difference in elk use within similar habitat types near the rig compared to an unaffected control site. After well site abandonment, elk levels near the drilling activity returned to former levels and the authors concluded that displacement was a short-lived phenomenon. Without marked animals, no way exists to determine whether the increased use following site abandonment was by former resident elk or immigrants from adjacent areas. Only one sighting of black bear was recorded during this study although the authors noted bear tracks near drill pads. In this area, neither elk nor bears had been hunted since 1965 and no information on recreational use of the region was presented. Elsewhere, elk subjected to hunting maintain considerable distance from roads, vehicles, and from people outside of vehicles (Ward et al. 1972, Ward 1976, Morgantini and Hudson 1979, Irwin and Peek 1979, Leege 1976).

Another inconclusive study relative to drilling rigs was conducted on mule deer by Ihle (1982) in Montana. Over time, that baseline study will prove useful, but drilling operations were too limited at the time of study to produce strong conclusions. Several radio-collared deer near active well sites indicated no obvious avoidance.

No other studies were found that related big game to full development of an oil and gas field. No one has examined the cumulative impacts of the various component activities of gas and oil exploration and development. Smith and Bloomfield (1980) discuss the component parts and mentioned another potential for impact which has not been studied: a blow-out. When a blow-out occurs, even at an isolated well, the rapid and intensive human disturbance could be overwhelming to wintering big game.

Other studies associated with oil and gas activity and big game are less applicable to the Overthrust Belt. MacKenzie (1976), Child (1974) and Cameron et al. (1979) examined oil/gas relations with caribou in the arctic and sub-arctic zones. These studies indicate a gradual, disturbance-related abandonment of range, occurring with increasing avoidance of adverse stimuli. This appeared especially so by cows with calves. Knight (1980) also observed cow elk with calves are more sensitive to disturbance than other elk.

The effects of oil and gas development on grizzly bears have been examined in Canada (Harding and Nagy 1980) and potential effects have been reviewed by Schallenberger (1980). Harding and Nagy (1980) tracked marked and unmarked grizzly bears in the Canadian arctic for four years and concluded that a population inhabiting an area near hydrocarbon facilities did not decline as a result of industry activities during the study period. They do, however, suggest that bears are affected by habitat lost to drilling camps and facilities and that bears have abandoned dens when seismic and excavating operations have been constructed nearby. Bears became a problem in staging camps even though garbage disposal facilities were deemed adequate to deter bears. Since at least 13 to 23 bears lived in the vicinity of these operations and only six instances of bears entering camps were reported during the four-year study, Harding and Nagy (1980) concluded that the general rule is avoidance of the camps by bears.

In his review of anticipated problems of oil and gas developments with Montana grizzly bears, Schallenberger (1980) iterated that prevention of human-bear confrontations is difficult and that developments in grizzly bear habitats would exacerbate such problems. However, without any information along these lines, impacts of oil and gas developments on grizzly bears in areas within the Overthrust Belt are unknown.

In Michigan, Bennington et al. (1982) observed only one black bear near an oil production facility during a 16-month study. Based on track counts and other bear signs, these investigators conclude that limited well drilling activity (one well per 5.2 km²) did not affect black bears, but minimal bear activity was noted near active drilling sites.

Road and Air Access. Similarities between seismic and well drilling activities and the effects of human disturbance associated with access roads in wildlife habitats are assumed and secondary impacts associated with increased access are of concern (Stubbs and Markham 1979). Monitoring locations and movements of radiotelemetered animals, Ward (1976) and Knight (1980) found that elk can become adapted to human disturbance of a repetitive or constant nature, such as continual traffic on forest roads. The primary effect appears to be one of reactions to humans when they are out of their vehicles. In southeastern Wyoming, Ward (1976) found that when vehicles along Interstate 80 stopped and people got out of cars, elk became more alert, spent less time feeding, and moved to cover. Knight (1980) also found seismic activities may disrupt breeding activities of elk. However, such observations of random disturbances have produced no details on the potential effects of disruption of breeding on subsequent reproductive success.

In general, the effects of activities along roads depend upon the big game species and the nature of cover adjacent to the road. Ward (1976) and Ward and Cupal (1979) found traffic has little effect on elk beyond 400 m in forest situations. Perry and Overly (1976) and Ward (1976) suggested that mule deer were less sensitive to traffic than elk. Using fecal-pellet group counts to indirectly assess deer and elk distribution and impacts of traffic, Rost and Bailey (1979) noted that roads and traffic have more of an effect in open, shrubby habitat than in pine and juniper vegetation. Ward (1976) found that the heaviest big game crossings of forest roads occurred where desirable feeding sites occurred, but were not necessarily related to the density of forest cover, as some have suggested (Lyon 1979).

Deer and elk respond more vigorously to people, roads, and vehicles in hunted versus non-hunted areas. Shultz and Bailey (1978) found non-hunted elk habituated to vehicles in Rocky Mountain National Park, Colorado. However, when people left their vehicles, breeding activities were disturbed because harem bulls were forced to spend more time defending and regrouping their harems. In Michigan, non-hunted elk returned to areas within one-quarter mile of a drill site several weeks after abandonment (Bennington et al. 1982). No pre-drilling elk distribution data were available for specific comparisons. Behrend and Lubeck (1968) determined that antlered white-tailed deer on a hunted area displayed significantly greater flight distances than on a non-hunted site. Furthermore, antlered deer response to people on the hunted area was significantly greater than antlerless deer on both areas suggesting that experience related to hunter preference modifies the response by the target sex and age class.

When roads in hunted areas are closed to the public, elk tend to respond positively to the closures. For example, Marcum (1976) reports that elk avoid roads open to vehicles, especially during hunting season. While elk in these areas avoided roads more than one mile away, elk in areas of road closures indicated no such aversion and used roads more than was expected by road availability. Likewise, Morgantini and Hudson (1979) note a shift of elk away from roads during a special hunting season with a return to pre-hunt distributions within one month of the season's end. Elk in Idaho sought out more ex-

tensive cover near heavily used roads but remained on preferred home ranges where roads were closed during the hunting season (Irwin and Peek 1979). Disturbances in elk habitat such as logging or road building appear to cause short-term displacements; the time taken by elk to return to the disturbance vicinity appears to depend on the duration of the disturbance activity (Hershhey and Leege 1976, Ward 1976, Thiessen 1976, Leege 1976).

The effects of road-related disturbances on mule deer, moose, and pronghorn displacements are not well documented. Using pellet group counts as a function of distance from roads, Rost and Bailey (1979) determined that mule deer avoided roads and that unimproved roads used by recreationists were implicated as well as gravelled roads. Paved highways apparently did not affect deer distribution. Similarly, mule deer wintering along Interstate 80 in southern Wyoming show little concern for traffic (Ward et al. 1980) and the main impact of this thoroughfare has been through vehicular collisions with big game (Goodwin and Ward 1976, Ward et al. 1976). Increased access and traffic volume have been held responsible for significant deer highway mortality (Arnold 1978, Wallmo et al. 1976). Mortality may increase when deer are attracted to palatable vegetation planted along highway rights-of-way and during migratory periods (Bellis and Graves 1971, Wallmo et al. 1976, Arnold 1978, Carbaugh et al. 1975, Ward et al. 1980). Wallmo et al. (1976) present estimates of mule deer and black-tailed deer killed on highways in several western states. For example, in 1974 an estimated 18,822 deer died as a result of vehicular collisions in California, Colorado, Nevada, New Mexico, Utah, and Wyoming (Wallmo et al. 1976). Impacts of highway-related mortality on local populations are not known. Goodwin and Ward (1976) reported maximum mule deer mortality during the fall migration of deer along a 55 mile segment of Wyoming's Interstate 80. During the 20-month study, about 48 percent of 219 road killed deer died from October through December. Mule deer were apparently attracted to the highway right-of-way during the spring "green up" of crested wheatgrass and approximately 15 percent of all road kills occurred during May when crested wheatgrass provided nutritious forage.

Moose distributions with distance from a disturbance source have been reported by Rolley and Keith (1980). These investigators determined that moose in Alberta avoided roads and occupied dwellings during the winter months (November to January) but did not offer information about traffic patterns or human activities. Moose have been reported to display no preferential use of seismic lines or snowmobile trails as travel lanes but do cross these avenues (Ferguson and Keith 1982, PRISM 1982). These observations contradict Horejsi's (1979) mention of moose using seismic corridors but are likely dependent on snow conditions and the use of trails by recreationists (Ferguson and Keith 1982). Nevertheless, increased human access through proliferate road systems and concomitant increased hunter harvests have been implicated in declining moose populations in Alberta, Newfoundland, and Quebec (Lynch 1973, Bergerud et al. 1968, Bider and Pimlott 1973). Goddard (1970) has shown that moose in hunted areas increase productivity when heavily harvested and little emigration of moose from unhunted areas occurs to fill unoccupied habitat.

The primary affects of roads on pronghorn antelope have been the restrictions imposed on movements by associated fence lines (Riddle and Oakley 1973, Mapston 1970, Sundstrom and Hepworth 1968). Fences have also been implicated in causing winter mortality to pronghorn unable to move to adequate winter range (Riddle and Oakley 1973). Recently, Segerstrom (1982) determined that humans on motorcycles and light vehicles in general, elicited the most intense reactions by pronghorns on a mine site in northeastern Wyoming. However, he did note overall lower pronghorn responsiveness to human disturbance on the mine site compared to a control area which may indicate pronghorn habituation to mine-related activities. Reeve (1982) suggested pronghorn habituation to vehicles where traffic volume is relatively high. But during the hunting season, pronghorn use increases with distance from main roads indicating displacement due to hunting.

The overall effect of roads in themselves are not usually thought of as being significant to the biology of big game. The primary potential impact on big game populations seems most related to car-animal collisions and the potential indirect effects of increased access to people. No quantitative studies are available which relate changes in population densities associated with increased access and potential illegal hunting. However, Smith and Bloomfield (1980) documented a rapid increase in legal harvest of elk in formerly inaccessible areas which were opened due to seismic exploration. As a result, they recommended closer regulations on hunting permits in Alberta.

The use of helicopters to transport survey crews and equipment appears to be a large factor in the overall effects of seismic exploration on big game. Lenarz (1974) examined influences of helicopters on dall sheep and moose in Alaska, and found that the sheep were much more sensitive than moose. However, the study did not adequately examine actual or potential effects of the displacement movements. MacArthur et al. (1982) found that helicopters passing Rocky Mountain bighorn sheep at distances greater than 400 m elicited no response. However, direct overflights of turbo-charged helicopters caused sheep to move away rapidly, although the running period was usually less than 65 seconds. Short-lasting, high intensity disturbances caused by helicopters appear not to cause long-distance movements, although experience shows that animals using open habitats move to the nearest available cover.

Pronghorn antelope also show escape reactions to helicopters. Luz and Smith (1976) determined that a helicopter flying at 150 ft. altitude and 500 ft. from pronghorn elicited escape behavior whereas no detectable response was observed when the air craft was at an altitude of 400 ft and 3000 ft away from the herd. However, at this distance, pronghorn became alert when the helicopter began an approach with simultaneous rapid descent. Bromley (1982) reports studies conducted by the US Department of Interior on the effects of helicopters and fixed-wing aircraft at various flight altitudes on diverse wildlife species. As expected, low-flying aircraft (at 200 ft altitude) elicit a greater reaction by caribou, moose, and bears at greater horizontal distances than when flying at altitudes of 500 and 2,000 feet. Harding and Nagy (1980) report that grizzly bears in the Canadian arctic show a strong aversion to aircraft and respond with more vigor and consistency to helicopters (88

percent of 17 encounters) than to fixed wing airplanes (61 percent of 36 encounters). However, grizzly bears in this study had been tranquilized from helicopters and the differential response to aircraft types may be a learned avoidance behavior (Harding and Nagy 1980).

Mining. Mining activities typically involve larger areas than are associated with oil and gas development. However, if full field development with associated support and treatment facilities is realized, the situation may be analogous to an operational mine. Big game response to coal mining is not widely documented. In Canada, Kuhn and Martens (1979) suggested that elk habitat utilization patterns in the vicinity of a coal mine might be altered through increased elk use of restricted hunting zones, increased foraging on reclaimed areas, use of rights-of-way clearings through dense forests, and use of drillhole seeps as mineral licks. The authors noted that direct and indirect harassment of elk by recreationists and increased hunting pressures are to be expected with mine development. They concede, however, that quantitative information with which to fully predict elk response to mining is lacking.

The US Fish and Wildlife Service has studied coal mine effects on deer in Montana since 1976. Using marked and radio telemetered deer, deer mortality due to human disturbances has been addressed. For example, 39 marked deer were killed by either vehicles (29 percent), legal hunting (26 percent), or poaching (18 percent) during 1978 (Biggins 1978). Furthermore, poaching is believed more prevalent than documented since marked deer have unaccountably disappeared. Harassment of white-tailed deer by mine employees was believed to have caused deer to abandon traditional winter range and move two kms away. Traffic mortality, poaching, and dog predation were problems faced by deer in the mine vicinity during other years (Biggins 1976 and 1977, Biggins and Phillips 1979).

Preliminary information collected on mule deer, elk and moose in the vicinity of phosphate mines located in southeast Idaho indicates that mining activities and facilities may impede mule deer migrations, especially if heavy snow accumulation is an aggravating factor (Kvale 1980). However, this interpretation is based on observations of only two telemetered deer that apparently crossed phosphate mines, taking a longer time to accomplish their migration than three telemetered deer that migrated around the mine boundaries. Kvale (1980) attributes the longer migration period to haul roads, rail lines and human activity but otherwise does not discuss what the two delayed deer were doing during this time.

Behavioral responses of pronghorn to various coal mining operations in northeastern Wyoming have been documented by Segerstrom (1982). Comparing behavior of pronghorns on a mine site with behavior on a control area, he found that animals on the mine site had habituated to most types of human activities with motorcyclists producing the most intense reactions. Variation from normal operating routines by heavy machines caused immediate escape responses by pronghorns although animals remained nearby when the machinery moved in predictable patterns. Additionally, telemetered pronghorn used reclaimed areas significantly more than availability would suggest.

Recreational Activities. Increased human populations associated with growth are expected to increase demands for consumptive (hunting) and non-consumptive use of local big game populations (Smith and Bloomfield 1980, Stubbs and Marcum 1979, PRISM 1982). Relevant literature dealing with disturbances to hunted versus non-hunted populations has been addressed as well as big game responses to human access. Primary problems associated with recreation effects on big game may be related to the nature of the disturbance over time and space. As Geist (1971) pointed out, common disturbances that are localized in time and space facilitate learning by animals and avoidance may be possible. He further stated that unpredictable, frequent disturbances are likely to be most detrimental since learning to associate the disturbance with a particular place or time does not occur and the animal is continuously confronted by the stimulus. In this context, big game responses to humans outside of vehicles have been more severe than response to moving or stationary vehicles themselves (Kucera 1976, Richens and Lavigne 1978, Schultz and Bailey 1978, Ward et al. 1972, Ward 1976, MacArthur et al. 1979). For example, Schultz and Bailey (1978) have shown that the mean flight distance of wintering elk was significantly greater ($p < .05$) when elk were approached by walking humans ($\bar{x}$ = 85.8 meters) compared to approach by cars ($\bar{x}$ = 76.8 meters). Similarly, elk escaped by trotting from humans approaching on foot 79 percent of the time compared to 46 percent when approached by cars. MacArthur et al. (1979) also reported that bighorn sheep escaped from humans on foot on 30 percent of 20 occasions but vehicular traffic only elicited an escape response in 2 percent of 49 observations.

Working with heart-rate telemetered elk, Ward and Cupal (1979) found that loud, irregular noises, such as sonic booms and gunshots, walking humans, humans with dogs, dogs alone, and trail bikes consistently produced positive heart-rate responses indicating acute awareness of the stimulus. By contrast, highway traffic, stopped and moving cars, and airplanes had less of an effect on elk heart-rate. However, the strength and recurrence of heart-rate response to the various stimuli increased with decreasing distance between the animal and disturbance.

As discussed previously, it has been found that big game may become accustomed to constant, localized disturbances, such as those associated with a single drilling rig in dense forest. In other cases, big game have been shown to become more sensitive following repeated disturbance rather than habituate. MacArthur et al. (1982) conducted experiments in which they purposely disturbed Rocky Mountain bighorn sheep in several ways, including an approaching human with and without a dog. As the experiments progressed, they noted sheep began to respond to minor disturbances which normally elicited no response. It is unknown whether the same applies to other large mammals disturbed by oil/gas activities.

Increased human access to wilderness areas may have more direct effects on wildlife and humans both. Hinman's (1974) and Klein's (1979) reflections on wildlife problems with oil development and pipelines associated with Prudhoe Bay, Alaska, point to industry personnel-bear conflicts arising from poor

garbage disposal practices and feeding bears and other carnivores. Public use of grizzly bear habitat has raised management problems in Alaska (Faro and Eide 1974) and in National Parks (Chester 1980). Problems associated with bears and oil company personnel are anticipated in Montana (Schallenger 1980). However, Elgmork (1978) has documented brown bear avoidance of human use areas such as roads and recreational cabins in Norway.

Studies of General Applicability to the Overthrust Belt

Other studies bearing on big game-oil/gas relations are discussed according to general topic and are summarized to indicate utility for interpretations of overall relations with oil and gas exploration and development.

Relevant studies useful in areas with elk include studies on calving by Johnson (1951) in Wyoming and Roberts (1974) and Schlegel (1978) in Idaho. Others include elk-logging studies by Hershey and Legee (1976, 1979), and Irwin and Peek (1979, In Press) in Idaho; fire ecology efforts by Legee (1969) and Orme and Legee (1976); other forest relationship studies by Black et al. (1976) in Oregon; Burbidge and Neff (1976) and Reynolds (1966) in Arizona; Marcum (1975), Lyon (1979), and other unpublished accounts in Montana; and Gruell and Roby (1976), Ward (1976), Long et al. (1981), and a habitat use study by Long and Irwin (1982) in Wyoming. Those reports primarily provide comparisons of elk habitat use in relation to logging or other disturbances which can be compared to patterns exhibited by elk in relation to oil and gas activities. For example, they were used to provide logging prescriptions for elk habitat in coniferous forests in the Rocky Mountains.

A broad variety of elk food habits studies are summarized by Kufeld (1973). Recent efforts on elk (Baker et al. 1982, Irwin and Peek 1983) provide more details on elk food and habitat preferences, but studies of interactions between habitat changes and population changes are few.

For mule deer, a host of studies on food habits, summarized by Kufeld et al. (1973), and habitat use studies (Wilkins 1957, Lovaas 1958, Julander and Jeffery 1964, Loveless 1964, Mackie 1966, Julander 1966, Richens 1967, Mackie 1970, Wallmo et al. 1976, Leckenby 1976, and Severson and Carter 1978) seem sufficient to predict outcomes of habitat changes on mule deer populations. However, research on spatial relationships and cover preferences has been meager and detailed, quantitative analyses involving testable hypotheses of functional relationships of deer habitat selection are not found in the literature.

Studies have been conducted by numerous investigators to show how prescribed burning (Martin 1978, Willms et al. 1981), fertilization (Anderson et al. 1974, Bayoumi and Smith 1976, and Mereszczak et al. 1981), and mechanical treatments (Strickland 1975, Black et al. 1976, Short et al. 1977) can improve deer habitat, but no one has evaluated habitat improvement in terms of population dynamics. Moreover, most available sources emphasize forage relationships in habitat management for mule deer (Leopold 1933, Klebenow 1965a, Crouch 1981) but almost no work rated cover quality as necessary. Most previ-

ous research relied upon visual observations, such as Martinka (1968) and Keay and Peek (1980). Others used pellet group distributions (Short et al. 1977, Julander and Jeffery 1964, Barrett 1979, Wallmo and Schoen 1980). However, Collins (1981) found pellet group analyses to be a poor technique. Thus, habitat selection data for deer are poor in comparison to work on food habits and nutrition.

Moose and pronghorn studies relating human disturbances to habitat are also few in number. There are food habits studies of moose (Peek 1974) and habitat use studies (Houston 1968, Knowlton 1960), and reproductive studies (Peek 1962, Schladweiler and Stevens 1973), but none are definitive enough to make predictions regarding impacts of oil and gas activities. The same is true for antelope, although recent studies (Barrett 1982, Hoskinson and Tester 1979, Amstrup 1980, Seegerstrom 1982) have greatly improved scientific knowledge.

Habitat-related studies which will be useful for comparisons within the Overthrust Belt are forest classification systems (Daubenmire and Daubenmire 1968) in northern Idaho; Ellison's (1954) work in the Wasatch Plateau, Utah; Mueggler and Harris (1969) in mountain grasslands of central Idaho; forest habitat types in Montana (Pfister et al. 1974) and Wyoming (Cooper 1975); and land typing systems for the northern Rocky Mountains (USDA, Forest Service 1977, Wendt et al. 1975). The combination of big game habitat use references and these studies of habitat classification will help provide objectives and methodologies for Phase II studies.

Summary of Literature Review

In general, most big game studies directed toward assessing oil and gas and associated human population impacts have lacked adequate controls. This is a valid criticism of many field studies which have been of a descriptive, rather than experimental, nature. Additionally, most studies have been short-term, baseline inventories that indicated displacement but precluded either immediate or long-term interpretations of relationships with big game population dynamics. Many were in the form of unavailable, unpublished theses or reports which described no testable hypotheses and had no strong theoretical basis for research. Interpretations from many previous efforts are confounded due to a lack of precision in field sampling techniques and statistically valid replication. In summary, these studies reflected displacement of large mammals without examining the actual or potential effects of the displacements.

Wildlife managers fear that oil and gas activities will result in decreased big game populations because of increases in legal and illegal harvest and because displacement may result in animals using more marginal habitats. They fear that displacement also may cause habitat degradation due to larger densities than can be supported by current carrying capacities in areas adjacent to oil and gas areas. Similar hypotheses have been made for big game displacements due to other disturbance sources such as mining, logging and roads. Increases in legal hunting and poaching have been noted when

big game habitat is open to public access and when occupied by a local work force. Displacement of big game away from disturbance sources has been documented for some species under various conditions. Big game behavioral and physiological responses to disturbance stimuli have been analyzed relative to human disturbances that are unpredictable in time and space and cause avoidance escape behavior or alert-alarm responses. There is no literature available which clearly describes population changes resulting from disturbance that produced displacement, excess energy expenditure, or how disturbance may influence production and survival of young.

Summary of Data Gaps

Frequently, biologists claim ability to predict effects of disturbances and habitat manipulation in terms of changes in animal numbers. This is difficult to measure and these predictions are virtually useless unless knowledge of limiting factors and factors affecting distribution are incorporated into the predictions. Because population size involves factors such as illegal and legal hunter harvest and weather patterns which cannot be controlled, predictions of habitat use and the potential effects of changes in habitat use on habitat/animal interactions currently offer a more realistic and useful approach than predictions of population size. The problem involves interactive effects of factors which influence habitat selection and subsequently influence population dynamics. Fortunately, useful multivariate analytical techniques are available, which will also prove useful in evaluating cumulative effects and thresholds for various components associated with development.

The crux of the disturbance-displacement-population impact issue was summed by Tyus and Lockhart (1979), who felt that more information is needed on factors which influence or regulate animal populations. Data should be available on big game-habitat interactions, food quality, cover requirements, and disturbance-related behavior. Studies of physiological condition alone are not a satisfactory substitute for direct evaluations of habitat/animal interactions. Precious little is known about how increased densities caused by animal displacement influence the population/habitat interaction. This problem requires details of intra-specific resource division and how it influences population distribution, reproduction, and survival (MacArthur et al. 1979). This suggests a hypothetical framework in which population densities influence home range selection and habitat selection (Fretwell and Lucas 1970).

Previous habitat use studies lacked a theoretical framework. Previous big game habitat use studies compared habitat use patterns of an individual or a group of individuals with availability over a large area, but Peek et al. (1982) argue that can only be determined within a home range. Home range selection and habitat use must be known. Population size and habitat suitability must be understood.

The vulnerability of a big game species or population to disturbances may vary with prior disturbance history, stage in the annual cycle, sex, and age of the animals being affected, as well as the nature of the particular distur-

bance, availability and distribution of habitat requisites, and the presence of limiting resources. Clearly, prediction of impacts is a complex problem.

Long-term studies are needed to assess impacts of development on big game species within the Overthrust Belt. Predictive models for use in future developments should be developed and specific variables associated with disturbance must be used. Studies must be conducted over a period of time to yield good results. Data must be collected on control and experimental areas (Green 1979).

Available literature can be used to identify general habitat characteristics that are important to big game species and general distribution phenomena that are dependent on changes in the species' annual cycles. But specific information on both habitats present and distributions of big game species is needed before critical habitats and important resources can be identified. Additional information on big game-disturbance relationships during all life history phases is necessary to identify time periods of particular sensitivity and areas of importance for a particular species. Thus, habitat information with distributional information is needed to identify areas that are important, critical, or sensitive at a specific time of year. Further, areas with potential for habitat improvements may also be identified. Other data gaps on the effects of disturbance on the welfare, survival, and reproductive potential of big game species are evident from the literature review. Ultimately, impact assessments address the effects of development on wildlife populations levels, but specific cause and effect relationships are lacking.

FURBEARERS

Introduction

The major furbearing species occurring in the Overthrust Belt are the fox, coyote, bobcat, pine marten, badger, mink, raccoon, beaver, and muskrat. The first five are primarily terrestrial mammals while the last four are associated with water in riparian or wetland habitats. In Wyoming, skunks are classified as predators although their fur has economic value (Thomas 1971). Uncommon furbearers in the study area include the river otter, fisher, and lynx. Wolverines are also known to occur in northwestern Wyoming (Hoak et al. 1982) but they are listed by the Wyoming Game and Fish Department (1977) as rare.

Very little information has been published which addresses the influence of oil and gas development on populations of fur bearing mammals especially in the Overthrust Belt. Topics such as road building, logging, grazing, and hunting or trapping have been dealt with more extensively. Since certain aspects of these activities parallel those associated with the petroleum industry (eg. construction of drilling pads and access roads, extraction of oil) literature dealing with these topics is included in this review.

Literature Overview

Most literature relating oil and gas developments to impacts on furbearers deals with arctic species, specifically arctic foxes (Urquhart 1973), Eberhardt et al. 1982). Direct impacts associated with the Trans-Alaskan pipeline (Klein 1979) and potential secondary impacts on potential prey populations along the pipeline and haul road (Brink 1978) are reported. Elsewhere, the effects of oil well drilling on bobcats have been examined (Bennington et al. 1982). The effects of oil spills on aquatic mammals are not well known (King 1980) but muskrat and beaver appear to be susceptible to oil contaminated waters in Wyoming (Strickland 1980).

Additional information related to habitat alteration and manipulations for both terrestrial and aquatic furbearers was examined for applicability to land use changes associated with oil and gas development. The effects of such practices as logging and grazing on terrestrial furbearers (Dixon 1925, Bailey 1976, Koehler and Hornocker 1981, Hillman and Sharp 1978) and wetlands alterations on aquatic species (Gunsen 1970, Houk 1942, Grasse 1951, Wilson) were reviewed in this section.

Studies on the Effects of Resource Development on Furbearers

Oil and Gas Industry. Generally, the available literature indicates that site clearing, drilling pad operation and road construction can have four primary impacts on terrestrial furbearers. First, these activities might result in the loss of some vegetation and habitat supporting small mammals or other prey species (Bennington et al. 1982). Elimination of specific habitat components such as areas of prey concentration and rock ledges has an effect on species such as bobcats, foxes, and coyotes, which depend upon these areas for denning and hunting (Brink 1978, Thomas et al. 1979). Second, road construction connecting dispersed drill sites may result in fragmenting the habitat, which may interrupt movement of mammals (PRISM 1982). Roads are sites of poaching activity (Klein 1979). Third, road and drill site construction causes many furbearers to disperse into outlying areas (Bennington et al. 1982). Displacement from drilling operations is believed a short-term response, because furbearers return to the area within two to four weeks after drilling operations stop (Bennington et al. 1982). The fourth potential impact results from accidental blowouts, spills, or leaks of reserve pit fluids, poison gas and oil. Terrestrial furbearers are very mobile (Vaughan 1978), consequently toxic leaks may not result in direct mortality but would cause them to leave the area. Conversely, aquatic furbearers are more confined and are susceptible to habitat contamination due to oil spills and other industrial contamination.

Eberhardt et al. (1982) evaluated home ranges of arctic foxes through field observations in an oil development area in Prudhoe Bay, Alaska. Foxes

used oil-development sites for feeding, resting, and denning. Urquhart (1973) reported that arctic foxes avoided oil exploration camps on Banks Island, Northwest Territories, during summer, and suggested this was related to decreased availability of natural foods in the exploration camps. It is possible that the garbage food sources at Prudhoe Bay may have contributed to the different observations in the two areas (Eberhardt et al. 1982). The implication is that a territorial predator, with tendencies for cyclic population fluctuation, will not be immediately influenced by oil and gas development. Nevertheless, furbearers attracted to staging and exploration camps because of available garbage or because of feeding by camp personnel may be a potential hazard if they become rabid (Klein 1979). Bennington et al. (1982) found that bobcats in Michigan were apparently absent on abandoned and producing oil well sites but utilized trails and roads in conifer stands. These authors report that bobcat activity decreased within one quarter mile of active drill sites but returned to previous levels within two to four weeks after sites were abandoned. However, they provide no data or discussion of data to substantiate this assertion.

According to available data, oil contamination of aquatic habitats has a direct effect on aquatic furbearers. Reporting on the Santa Barbara, California, oil spill problems, King (1980) states that effects on seals and sea otters were not well known. She suggests that marine mammals are less affected by oil spills and contamination than birds. Nevertheless, Kooyman et al. (1977) have shown that thermal conductance of sea otters and fur seals increases when coated with crude oil. However, crude petroleum entering fresh water habitat is likely to have more noticeable consequences on furbearer residents since their activities are concentrated within narrow limits of a watercourse. In Wyoming, an oil spill near Glenrock lead to the death of at least 11 muskrats, 4 beavers and 1 raccoon (Strickland 1980). Limited necropsies on affected mammals demonstrated oil penetration and accumulation in the hair down to the skin. McEwan et al. (1974) have shown that muskrats covered with crude oil have higher metabolic rates than unoiled animals to compensate for heat loss associated with oiling. Strickland (1980) suggests that afflicted furbearers in the Glenrock, Wyoming, incident may have succumbed to hypothermia because of the oiling.

Roads. The literature indicates that increased road systems and human access may affect furbearers in several ways. In Alaska, Klein (1979) states that poaching of furbearers along the Trans-Alaskan pipeline haul road has increased even though industry related traffic on the road has decreased. The implication is clearly directed toward increased use of the road and violations by the unauthorized public, although Klein (1979) does not provide any data on either road use or on illegal furbearer harvest. Reports of increased furbearer mortality due to vehicular collision are unknown.

Effects of roads on furbearer prey populations are more subtle than direct mortality through increased poaching described by Klein (1979). Brink (1978) demonstrated increases of rodents with distance from the Trans-Alaskan pipeline and haul road. She attributed the relationship to vegetation changes caused by construction of the corridors. She also observed various mammalian

and avian predators successfully capturing prey along the right-of-way, apparently unaffected by the road disturbance. Revegetation of rights-of-way has the potential to positively affect rodent populations (Baker 1971) and may attract furbearing predators to roadside areas. Though this has not been documented, furbearer mortality along revegetated roadways is hypothesized to increase due to vehicular collisions.

Studies of General Applicability to the Overthrust Belt

Terrestrial Furbearers. Logging and grazing patterns influence furbearing mammals (Dixon 1925, Bailey 1976, Hillman and Sharp 1978). Clear-cut logging practices eliminate habitat for some and increase the amount of traffic and harassment in remote areas. Logging practices can provide parks and new habitats for small mammals and may benefit furbearers by increasing the biomass of prey species. However, Koehler and Hornocker (1981) found that clear-cut logging decreased some prey species (squirrels and voles) used by pine marten in Montana, but increases in deer mice and ground squirrels compensated for those losses; so, there was no net effect. In addition, the data indicates prudent logging practices can enhance the quality of habitat for some furbearers. For example, any type of tree harvest may benefit red foxes, especially if regeneration is in irregular shapes to maximize edge. Yearsley and Samuel (1980) found that maximizing edge would aid utilization of areas such as reclaimed surface mines by fox. Another example of discriminate logging would be to leave small woodlands near riparian habitat and avoid cutting trees with obvious or potential hole nests for raccoons (Stuewer 1943, Butterfield 1950). Doing so would enhance the survivability of raccoons in timber harvest areas. On the other hand, moderate grazing by domestic livestock appears to have little if any benefit to furbearers. Heavy grazing may negatively influence prey species availability for bobcats, but this has not been adequately examined.

Aquatic Furbearers. Aquatic or semi-aquatic furbearers are less mobile and have greater habitat restrictions than their terrestrial counterparts, thus they are more responsive to habitat change. The quality of wetlands habitat is known to influence the litter size and age of dispersal of beaver (Gunsen 1970). The beaver, in turn, is probably the most important biotic factor maintaining the constancy of the riparian habitat (Houk 1942) by enhancing the storage of water, elevating streams and aiding in the control of erosion. The water impounded by beaver activity becomes deeper, warmer, and higher in the production of plankton which, in turn, provides more suitable habitat for aquatic birds (Lochmiller 1979), waterfowl (Arner 1963, Beard 1953), other aquatic furbearers (Grasse 1951), and fish (Pullen 1967). The primary limiting factor of many muskrat populations is a fluctuating water level which influences the cover and the type and distribution of food plants (Wilson 1949).

Numerous natural swamp areas characterized by meandering, sluggish streams have been channeled and straightened by private and government agencies. This causes changes in the wetland habitat. Hamerstrom and Blake (1939) found that dikes that were well shaped or were adjacent water ran deep

and swift were practically unused by muskrats. In addition, channeling frequently causes flooding in one part of a swamp, while other backwater areas become dry (Gray and Arner 1977). Diking and ditching can be beneficial to wetland furbearers if done correctly. For example, the construction of pot-holes in excess of one meter deep will reduce mortality of muskrats by preventing the solid freezing of the wetland habitat (Anderson 1948).

Little work has been done on evaluating the range of water quality that aquatic furbearing mammals will tolerate. The literature indicates that river otters are not found in waters altered by acid mine drainages (Mowbray et al. 1979). Downstream effects of water contaminants such as crude oil and mine effluents on furbearers are unknown; only "worst case" events have been documented (eg. Strickland 1980), and sub-lethal, chronic contamination influences on furbearer biology have not been investigated.

Summary of Literature Review

No definitive studies of the effects of petroleum industry development on furbearer species occurring in the Overthrust Belt have been found. From relevant literature dealings with arctic species, furbearers appear to be adaptable and capable of exploiting food sources created in areas of human development and may be expected to at least maintain their numbers. Yet, very little basic biology is known for Overthrust Belt species such as the wolverine, fisher, lynx, and river otter that can be used in impact prediction. Other species, including opossum, raccoons, and red foxes, have extended their historical ranges coincidentally with the development of western landscapes for agriculture, timber, mineral, and range resources (Crowe 1981).

Other furbearing species have declined in the face of industrial and agricultural expansion. These include black bears, bobcats, and probably marten and badgers. The aquatic-associated furbearers, mink, muskrats, and beavers, may fluctuate more due to natural population cycles, but can be heavily influenced by water quality changes which would be associated with altered water levels, oil spills, or leaks of reserve-pit fluids.

Changes in land use may affect terrestrial and aquatic furbearers in different ways. Creation of forest openings and edges is apt to enhance utilization by certain species either through prey response or as travel corridors. But human manipulations of wetlands may have deleterious effects on aquatic furbearers if water volumes are reduced to suboptimal levels. On the other hand, furbearers, principally beaver, can have profound influence on wetland habitats that enhances conditions for other fish and wildlife species. Deterioration of water quality through industrial accidents will affect aquatic furbearers more severely than terrestrial species.

Summary of Data Gaps

Broad generalizations of information shortages associated with this wildlife group are difficult because of the various taxonomic categories, habitat requirements, and food habits of the representative species. Additionally,

differential mobility contributes to predicted differences in susceptibility to terrestrial and aquatic habitat alterations. There are no studies examining movements of terrestrial furbearers in relation to development: unequivocal documentation of avoidance and resultant displacement is absent and there is no evidence showing use of suboptimal habitats by displaced furbearers. No studies have been conducted on tolerances of aquatic species to nearby human disturbances. Levels of sedimentation in wetlands and critical levels to muskrat and beavers resulting from erosion of disturbed surfaces have gone unreported. Likewise, sensitivity of different species to impacts during different seasons and stages of life cycles is unknown. In short, there are some very basic questions in need of answers before any estimate of furbearer population change due to disturbance can be made. In fact, population estimates of furbearers, especially of terrestrial species, are often difficult to determine and are usually absent in wildlife inventories.

RAPTORS

Introduction

Raptors are large birds of prey such as hawks, falcons, owls and vultures. All of these birds are found in the Overthrust Belt. Raptors have been the subject of harassment because they have been seen to take livestock and eat wildlife species sought by the hunter (Phillips, personal communication). Actually, raptors are important component of the ecosystem and are of economic value. When human disturbance causes a decrease in the raptor population, a number of mammal populations including rabbits, small rodents, and prairie dogs generally increase. An increase in these populations reduces the food available for livestock and wild ungulates. Some raptors, particularly vultures and bald eagles, assist in the decomposition process in the ecosystem when they feed on carrion.

Between the late 1950's and the early 1970's, raptor populations declined and, in some areas, disappeared, due to the use of pesticides. This has been particularly true of the peregrine falcon in the eastern United States. Recent studies indicate, however, that the problem is declining as a result of bans on some persistent pesticides (Stickel, personal communication).

Because raptors are high on the food chain and they were impacted by pesticides during the past 25 years, many species have declined to levels where they have been declared endangered or are of concern and listed as birds of high interest. As a result, special management considerations must be made when working in areas where raptors are found.

Literature Overview

Numerous recommendations related to human development restrictions in raptor nesting habitat have been advanced, but few investigations of development effects on raptor populations have been conducted. This is true of activities associated with the petroleum industry. General effects of human disturbance on raptors has been reported by Olendorff et al. (1980) and Sutter

and Jones (1981) provide a review of buffer zones recommended for raptor nest sites. Olendorff et al. (1981) have addressed specific problems associated with raptor use and mortality on transmission line structures and Nelson (1978) provided recommended utility pole modifications. Additionally, Fitzner (1975) has examined impacts of fence and transmission lines on owls.

The effects of mining activities on Wyoming raptors have been investigated by Phillips and Beske (1982), Lockhart et al. (1980) and McEneaney and Lockhart (1978). Timber harvest impacts on ospreys were studied in Arizona (Adams and Scott 1979) and effects of explosives on red-tailed hawks are documented in an unpublished study by Alldredge and Shickler in northwest Colorado. These impact sources have applicability to potential impacts occurring during oil and gas development and are discussed in this section.

The literature indicates possibilities for improvements of raptor habitat exist by manipulating prey species abundance (Olendorff and Stoddard 1974, Baker and Frishknecht 1973) and nesting sites (Phillips and Beske 1982, Olendorff and Stoddard 1974, Olendorff et al. 1980). Thus the use of artificial nests and the movement of raptor nests from sites of disturbance have been successful. Maintenance of proper cover so rodent and rabbit populations are abundant assists in maintaining raptors. Raptors in turn assist in keeping many pest species in check.

A study by White (1974) indicates that increased human access is expected to adversely affect raptors. Raptor poaching is anticipated to increase with development in the Overthrust Belt (USDI Bureau of Land Management 1979). While some species of raptors do partially adapt to the presence of people they do need time when disturbance is at a minimum. (Anderson, personal communication).

Aspects of raptor nesting requirements and food habits have been reported for various species occurring in the Overthrust Belt and are included as relevant information useful in future investigations.

Studies of the Effects of Resource Development on Raptors

Oil and Gas Industry. No studies have been found specifically addressing the impacts of petroleum industrial development on raptor species. However, since developments require supporting facilities such as powerlines and roads, the known and predicted interactions of raptors with these structures and disturbances are included here.

The literature indicates that raptors are adversely affected by an increase in human population. If disturbances are extensive, raptors may leave the area and not return. Another problem associated with human impact on raptors is irresponsible shooting. This is perhaps one of the most harmful impacts on raptor populations. Additionally, raptors feeding on road-killed wildlife may, themselves, be killed (USDI 1979).

A study by Olendorff et al. (1980) indicates that human disturbance to

raptors is particularly detrimental during the breeding season. Each of the raptors breeds at a slightly different time. Many of the owl species begin setting up territories during the mid winter. Most of the hawks and falcons establish their territories and begin nesting activities in March and April and carry them on into early June or July depending on climatic conditions (Fyfe and Olendorff 1976). Suter and Jones (1981) have reviewed recommended buffer zones for reducing human disturbance at nest sites of various raptor species and conclude that extended activities should be at least one km away from active nests to reduce the possibility of nest abandonment. Further, they recommend the use of temporal buffers -- that is, human avoidance of nests from the time of adult raptors' arrival through the nestling period.

Adams and Scott (1979) discuss the impact of timber harvest around an osprey nest in Arizona. They describe how ospreys were disturbed whenever people approached the nests. The results showed that ospreys failed to use their nest during the year following timber harvest, but returned the following year when human activity in the area was reduced. Alldredge and Shickler's unpublished data revealed that four of 13 red-tailed hawk pairs abandoned their nests following detonation of explosives near Rio Blanco, Colorado. The other birds seemed extremely nervous immediately after the detonation. No second-year study was made.

According to the literature, a common source of raptor mortality associated with industrial development is electrocution on transmission lines (Oak Ridge Associated University 1978; Olendorff et al. 1981). High towers, such as those associated with communication stations, are an additional source of mortality to raptors as well as other birds (Avery 1978). Special considerations for marking towers with lights at night and some form of color markings during the day can reduce impact. Placement of transmission lines on the downslope of hills, as well as below the tree line, will reduce impact. Nelson (1979) recommends specific techniques for pole construction. A field study by Fitzner (1975) showed fences and utility lines were responsible for death of short eared and great horned owls.

The literature suggests that roadways do not pose as great a hazard to raptors when considerations are made for placing them in areas away from major flight patterns. The biggest concern about roadways is subdivision of habitats to the extent that the prey base is reduced, thereby preventing raptors from searching and finding food (Olendorff et al. 1980). There is some concern that raptors are attracted to roadside structures and may be killed when traffic becomes heavy (O'Brien, personal communication).

Olendorff and Stoddard (1974) indicated that the largest most closely controlled private ranches in northeastern Colorado had the best habitat for resident raptors. This study indicates the importance of maintaining isolated habitat for raptors. In these areas, human disturbance was minimized at nests and an adequate prey base remained. White (1974) points out that the greatest threat to raptors may occur after the construction phase of any activity. In this review paper on raptor conservation he refers to the Arctic and points out that once the area has opened, the general public may move in. This

presence of human activity has a severe impact on the fate of local populations. Thus, individuals involved in development of important wildlife areas should consider restriction of public access and education activity to ensure that people understand the importance of raptors. The review provides some good ideas to consider in raptor management.

Mining. Raptors nesting on and near coal mine leases in Wyoming and Montana have been monitored by personnel with the US Fish and Wildlife Service. Although no specific impacts due to coal mining per se are discussed beyond habitat elimination, raptor mortality has been documented due to electrocution and vehicular collisions (Phillips and Beske 1982). Home ranges of golden eagles inhabiting a strip of mine area in southern Montana were determined but no hypotheses centering on the effects of human activity on these home ranges have been reported (McEneaney and Lockhart 1979).

Studies of General Applicability to the Overthrust Belt

An excellent review of raptor management is Olendorff et al. (1980). They review management approaches, legislation, and species needs. The authors discuss the potential for management in western grasslands based on current literature. They discuss the use of artificial platforms and nest boxes and present methods of managing land around raptor nests. They also describe in detail several other habitat management techniques. Much of the information is applicable to the Overthrust Belt. The review also contains an extensive bibliography. Kennedy (1980) has reviewed information requirements needed for raptor species inhabiting energy development areas in the western U.S. She stresses the use of procedures that will enable researchers to test hypotheses relating impacts to population change over short- and long-term durations on the specific areas being developed.

According to Olendorff and his coworkers (1980) if individuals conducting changes in raptor habitats plan carefully, they can often institute management procedures which actually enhance raptor habitat. There is a great deal of potential for management of raptor populations, particularly in western grassland. Some of these procedures are discussed in Olendorff and Stoddard (1974).

Fyfe and Olendorff (1976) indicate that a number of tested techniques that can be used to manage populations. If native habitat can be left undisturbed, raptor populations often will remain in the area even though human activity occurs around the fringes. When habitat has to be disturbed, plans can be made to avoid the breeding season for the majority of species (Olendorff et al. 1980). It is important that when removal of active vegetation occurs reseeding be done as soon as possible. For example, removal of juniper from native sagebrush/grassland habitat followed by effective reseeding was shown to increase the prey base of rodents for at least two years (Baker and Frishknecht 1973).

Several studies indicate that prey abundance does affect ferruginous hawk productivity (Smith and Murphy 1978, Smith et al. 1980) and golden eagle

productivity (Kochert et al. 1980). Great horned owls nesting success has been shown to increase with concomitant population growth of snowshoe hares, apparently a preferred food item (Rusch et al. 1972).

Conversely, the Olendorff study (1980) indicates reduction in prey population has been the cause of declines in raptor populations. Human activity often results in a decrease in rabbit, small bird, and rodent populations which are taken by a number of raptors. When this occurs, the raptor population declines and may not return to its predisturbance level.

A general review of raptor nesting habitat requirements for species found in the Rocky Mountain area has been produced by Call (1978). Raptors generally require specific sites in which to nest. Vultures, for example, use rocky cliffs for nests (Maser et al. 1979). These areas are also used by prairie falcons and golden eagles. Goshawks, sharp-shinned hawks, and Cooper's hawks use forested areas (Williams and Matheson 1973). All three of these species are found in the Overthrust region. The goshawk generally prefers dense evergreen forest, but clumps of trees along canyons and moist draws are used for nesting. Sharp-shinned hawks are also found in evergreen forests but will nest in other forested areas, particularly near streams. The Cooper's hawk uses dense aspen stands which are common in the Overthrust Belt (Jones 1979).

A 1980 study by Winternitz discusses the importance of dense aspen stands as habitat for many wildlife species. The importance of riparian sites for raptors has also been discussed by Henny and his coworkers (1978). Swainson's hawks and golden eagles nest in trees along moist canyons (Olendorff and Stoddard 1974). When marshy habitat exists, these sites are also ideal for ground nesting marsh hawks (Williams and Matheson 1973). Osprey may nest in riparian habitats and wintering bald eagles roost in the trees (Henny et al. 1978). The trees also provide homes for many of the owl species that are not commonly seen during the daytime. Riparian habitats and vegetation along streams are important for raptor nesting, especially Swainson's hawk (Dunkle 1977). The literature also indicates that a number of species of raptors use the same nest sites year after year. Swainson's hawks and golden eagles both commonly return to their nests. Some of the owl species, for example, the great horned owl, often use nests that have been constructed by other birds. The great horned owl might nest in tree nests as well as niches on ledges or cliffs (Eyre and Paul 1973).

Several studies are underway to determine the feasibility of using artificial perching and nesting sites. The Bureau of Land Management is studying the use of perch sites in prairie dog towns for ferruginous hawks, red-tailed hawks, marsh hawks and golden eagles near Saguache, Colorado (Snow 1973). Artificial nesting platforms for ospreys have worked effectively (Olendorff et al. 1980). In a study in the Powder River Basin of Wyoming, golden eagles have been successfully moved from natural nest sites in cottonwood trees to artificial nest sites some distance from potential mining activity (Phillips and Beske 1982). The importance of knowing the biology of the bird came out in this study. The birds need to be moved within their territory. Olendorff and his coworkers (1980) discuss other examples of artificial nests.

Burrowing owls can be found in areas of short grass and sometimes around prairie dog towns. Burrowing owls nest in ground burrows and are often seen sitting around their burrows in the spring and early summer. These owls take a large number of insects and rodents and are an important component of the system (Zarn 1974a). By avoiding destruction of prairie dog colonies, as well as allowing sites where burrowing owls have nested to remain isolated, the burrowing owl population can remain intact.

A number of publications exist which will assist developers in the Overthrust Belt to evaluate the impact of disturbances on raptor populations (Williams and Matheson 1973, Eyre and Paul 1973, Olendorff et al. 1980, and Evans 1982). Reviews on the bald eagle (Snow 1973, Snow 1979), golden eagle (Snow 1973), prairie falcon (Snow 1974), peregrine falcon and spotted owl (Zarn 1974b) contain useful habitat and life history information.

Summary of Literature Review

Nesting habitat requirements for raptors likely to occur in the Overthrust Belt of Wyoming, Utah and Idaho are well documented in the literature. However, there is some variation in substrate use for some raptor species while others have shown little latitude in their use of nesting habitat. According to the literature, the most important consideration in management of raptors is maintenance of habitat and reducing human impacts. Species vary in their tolerance to disturbances, but all are most susceptible during the nesting period. Various authors recommend the employment of spatial or temporal buffers if developments must occur in nesting areas.

Although no studies examining specific oil and gas development impacts on raptors were found, literature related to parallel components, such as roads and transmission lines, was surveyed. Various raptor management techniques have been advanced ranging from utility pole design, fence line placement, manipulation of prey habitats, to the use of artificial nesting structures to compensate for lost nesting habitat.

Summary of Data Gaps

The consensus of the literature is that impacts on raptors result primarily from human encroachment, habitat subdivision, and nest site destruction. The degree to which different raptor species can withstand such changes over several nesting seasons is unknown. Conversely, resiliency of populations and of individual nesting pairs to return to either pre-impact levels or to specific nest sites after abandonment is unreported. Destruction of roost and nest sites can lead to the use of alternate sites; however, the amount of pressure birds will tolerate is unknown. The change in prey base influences nesting activity and productivity of raptors. None of these impacts are unique to oil and gas development. However, long-term studies are lacking which examine the interrelationships between development-related prey changes, nesting habitat made unsuitable by human activities and raptor population changes.

Habitat and unique features required by raptors in the Overthrust Belt are unknown and a general survey is needed. While some attention has been given to nesting raptors, very little has been directed at the effects of human developments on wintering populations of sedentary or migratory species such as the rough-legged hawk. Therefore, the survey might well include both breeding and winter populations and their respective habitat requirements in impacted and unimpacted areas.

GAME BIRDS

Introduction

Game birds include doves, partridge and grouse, cranes and various waterfowl. The Overthrust Belt supports a rich diversity of these species which provides many recreational opportunities. The diversity of game bird species is the result of habitats diversity. Waterfowl inhabit lakes, rivers, beaver ponds and wooded lakes, agricultural ponds, irrigated land, sloughs, marshes, turbulent mountain streams, and mountain meadows. Upland game birds are diverse in their habitat associations which include arid shrublands, agricultural areas, forested uplands, and alpine tundra (Wyoming Game and Fish Department 1977). Some game bird species only use the Overthrust Belt during migration. Consequently, the impacts of human development are likely to affect members of this wildlife group in a variety of ways based on affected habitats, habitat availability, and season.

Literature Overview

Impacts due to oil and gas development on terrestrial game bird species are similar to other industry-related disturbances such as road construction and coal mining. Habitat manipulations and management in areas supporting sage grouse and waterfowl are well documented (Klenbenow 1965, Quimby 1966, Kirsch 1969, Martz 1967, Gjersing 1975, Mundinger 1976, Call 1974, Braun et al. 1977, Kaminski and Prince 1981). Reclamation and mitigation of mining impacts on sage grouse habitat and breeding areas have been addressed by Colenso et al. (1980), Eng et al. (1979), and Tate et al. (1979).

The literature indicates that certain aspects of oil and gas development pose unique problems to game birds, particularly waterfowl. Waterfowl susceptibility to mud and sludge pits has been documented by Tully and Boulter (1970) in Colorado, Flickinger (1980) in Texas, and June (1973) in the Kemmerer, Wyoming, area. According to several studies, oil discharges into aquatic habitats can seriously affect waterfowl through toxicosis after ingestion (Szaro et al. 1978, Peakhall et al. 1980, Vangilder and Peterle 1980, 1981), hypothermia due to feather oiling (McEwan and Koelink 1973), and influence on reproduction before and during incubation (King and Lefever 1979, Grau et al. 1977, Holmes et al. 1978, Harvey et al. 1981, Albers 1978, Coon et al. 1979).

Other game bird studies related to habitat ecology and population status have been included. These reports have potential use as baseline and background documents should future investigations be initiated.

Investigators studying the effects of oil drilling activities on nesting waterfowl and other birds have presented differing study results. Working in the Canadian arctic, Barry and Spencer (1976) conducted field observations of nesting birds within 2.5 km of a drilling rig and on a more distant (8 km) control area. They reported that, for some species, occurrence and productivity were higher on the control area than compared to the area surrounding the drilling rig. They stated that whistling swans, white-fronted geese, Canada geese and snow geese avoided the drilling area more than other species of nesting waterfowl. There was a great deal of variation in their observations and this, along with the short duration of the study (one summer) precluded any firm conclusions to be drawn. In Alaska, Wright and Francy (1980, in Bromley 1982) also examined nesting success and species abundance through field observations on areas near and distant to a drilling rig. Nesting failure was noted but no patterns relating development and nesting success were discerned: bird species abundance, nesting density, and productivity were similar on the affected and control areas. Again, these observations were conducted for only one field season and over a limited area. Barry and Spencer (1976) and Wright and Fancy (1980) noted that helicopters caused nesting birds to leave the nest and Barry and Spencer (1976) speculated that increased nest predation was a possible factor in the decreased nest productivity noted near the drilling activity. They suggest that incubating adults flushed from the nest when helicopters approached and were visible to predators. No evidence for this hypothesis was presented. Stubbs and Markham (1979) have recommended protecting nesting waterfowl with a 100-meter buffer zone between well pads and the high water mark of the affected water body. They suggest increasing the buffer zone to 300 meters for colonial nesters and trumpeter swans implying these waterfowl are more sensitive than other species to disturbance (Stubbs and Markham 1979).

According to the literature, oil spills do pose a hazard to game birds, particularly waterfowl. The normal precautionary measures generally avoid such difficulties. If spills do occur, the effect can be a problem for several years. Specific recommendations are made in the Bergman et al. (1977) to minimize the impact of oil and gas development on wildlife. A contingency plan exists in the U. S. Fish and Wildlife Service outlining responses to oil spills. Success in getting bird recovery is generally low (less than 15 percent).

The mode of exposure to oil pollutants may include accidental contact of small amounts on feet and feathers, ingestion of contaminated food items, direct ingestion of petroleum products while preening feathers, or complete coating of the body and feather. A study by King and Lefever (1979) indicates oil is transferred from feathers of incubating adults to eggs.

Where small amounts of petroleum products are ingested, gross indicators can be used to monitor the presence or absence and the degree of impact. Grau et al. (1977) observed distinct changes in yolk structure and reduced hatchability of eggs from Japanese quail fed petroleum oils. Changes in oviposition, fertilization, egg size, shell thickness, or hatchability in birds ingesting small amounts of petroleum products have been reported by Szaro

(1979), Holmes et al. (1978) and Harvey et al. (1981). Some of these effects exerted by petroleum products are similar to those produced by DDT (Vangilder and Peterle 1980, 1981). However, reduced egg size and pathogenic changes in liver and kidney tissue characterize petroleum products' impact. Also, it is important to note in some investigations the variable toxicity of the petroleum products from different points of origin and of different grade levels. It is also important to note from the literature that some emulsifiers used to disperse oil products actually amplify toxic effects of oil pollutants.

Where birds have walked in oil or have a light film adhering to their belly region, such oil can cover eggs and have serious consequences for the encapsulated chick. Albers (1978) reports that early incubation stage eggs are most susceptible. Embryos less than 11 days of age died from egg exposure to five microliters of oil. This was further substantiated by the studies of Coon et al. (1979) on the great black-backed gull.

For those birds successfully hatching from eggs containing less than lethal doses of petroleum oils, problems of duckling survival following hatching are described by Vangilder and Peterle (1980). Where young nestlings or fledglings have escaped initial exposures through the egg, they may still succumb to problems resulting from ingestion of petroleum oils with food collection (Szaro et al. 1978, and Peakhall et al. 1982).

McEwan and Koelink (1973) have investigated the effects of crude oil on diving ducks. From experience with marine oil spills and contamination, diving water birds appear to be particularly vulnerable to oiling (King 1980). Oiled feathers deteriorate and lose water repellency thereby increasing heat loss and metabolic activity of oiled birds (McEwan and Koelink 1973). Death due to hypothermia has been suggested for afflicted waterfowl during an oil spill near Glenrock, Wyoming (Strickland 1980).

Besides actual oil spills, the literature indicates that waterfowl are potentially impacted by the presence of reserve, mud or sludge ponds. A limited summary of the impact of sludge or sump pits on waterfowl and other birds has been presented for the oil fields of the southern San Joaquin Valley of California (Audubon 1973) where the annual losses in 1700 pits were estimated to be 150,000 birds. A more detailed regional study in Colorado described the seriousness of the sludge pit problem (Tully and Boulter 1970). Of 1572 oil production sites, 469 were found to cause wildlife deaths attributed to reserve pits at the time of the survey.

The potential for waterfowl mortality in mud pits on the Bear River Divide area of Wyoming was studied by June (1973) who reported 116 waterfowl deaths on an evaporation pond near Kemmerer, Wyoming, during autumn 1973. Flickinger (1980) studied effects on other bird species and small mammals in Texas. Various mitigative alternatives to prevent losses on pits and ponds, among them the use of human effigies (Boag and Lewin 1980), explosive devices (June 1973), and covering areas with mesh wire (Washington Department of Game 1980) have been studied. Caster and Albers (1980) provide information which suggests birds, given the option, will try to avoid oil film on water or other

substrates when unoiled substrate areas are available. More research is needed on water surface feeding species since they apparently have the greatest difficulty avoiding oil.

Mining and Other Land Disturbances. Other habitat studies, while not specifically responding to habitat impacts by oil and gas activities, are relevant to that problem. Thomas, et al. (1979) have characterized common traits of riparian habitat; they discussed the importance of those riparian zones to wildlife and they identified factors which adversely affect the quality of that habitat. Effects of the loss of habitat or habitat manipulation on sage grouse and waterfowl have been well explored compared to other game bird species of the Overthrust Belt (Klebenow 1965, Quimby 1966, Kirsch 1969, Martz 1967, Gjersing 1975, Munding 1976, Kaminski and Prince 1981). Furthermore, Call (1974) and Braun et al. (1977) describe the habitat requirements of sage grouse, emphasizing the importance of sagebrush communities. Also, they prescribed the habitat management necessary for maintenance of shrub steppe communities as grouse habitat. Where sage grouse habitat has been destroyed, criteria for reclamation are presented by Colenso et al. (1980).

Where mining activities have threatened to eliminate sage grouse communal breeding grounds, researchers have tried to direct birds to artificial leks (Tate et al. 1979, Eng et al. 1979). In Wyoming, an artificially created lek was decoyed with lek sound recordings and paper-mache models but was sparsely visited by displaced grouse (Tate et al. 1979). A Montana effort to relocate breeding grounds was more successful with increasing sage grouse use observed over a two-year period (Eng et al. 1979). Both sets of investigators stress locating created leks in areas consistent with other areas used by grouse for nesting, brood rearing and wintering and that the new site should have similar vegetative and physical characteristics to existing leks. Nevertheless, where activities destroy or extensively modify a key avian breeding area, successful mitigation of that loss remains undocumented. During a study on the effects of strip-mine noises on displaying sharp-tailed grouse, Amstrup (1977) found that birds responded negatively to recorded mine noises by reducing or ceasing breeding activities on about half the treatment occasions. Amstrup (1977) felt that real mine noises would produce a more severe effect than the recordings thereby reducing lek productivity over time.

Like raptors, game birds are susceptible to mortality associated with utility lines although the cause of death has usually been attributed to collision rather than electrocution. Sage grouse collisions with telephone lines were documented in Utah (Borell 1939), and in Texas 52 sandhill cranes had succumbed to collisions with telephone and transmission lines during a fog (Tacha et al. 1978). Cornwell and Hachbaum (1971) maintain that duck collisions with transmission lines may be common on the northern prairies and they recommend routing utility corridors to avoid marshes.

Road and Air Access. Road construction associated with proliferating development eliminates terrestrial game bird habitat. The Bureau of Land Management (USDI, Bureau of Land Management 1979) estimates the areal extent

of direct impact on the landscape, but does not determine that impact for specific game bird species habitat. One report for the Trans-Alaskan oil pipeline (Brink 1978) addresses avian habitat impacts which can arise from secondary activities related to oil and gas production. Although this study deals with a tundra habitat, the general considerations have wider application.

Brink (1978) concluded that direct human disturbances in the form of bird-banding or nest checks had more serious effects on nesting birds than did disturbances due to traffic. However, fugitive dust associated with unpaved roads may become a problem. Brink (1978) noted deposition of dust on snow to at least 450 meters downwind of the Trans-Alaskan pipeline haul road. Vegetation along the road flowered and expired earlier than plants more distant because of earlier snow melt. Hanley et al. (1980, in Bromley 1982) noted reduced shorebird nesting density along roads to be partially caused by fugitive dust.

Response of game birds to aircraft have been studied by several investigators. Barry and Spencer (1976) recorded differential responses by waterfowl to fixed-wing aircraft and helicopters. Fixed-wing aircraft appear to cause less disturbance on nesting waterfowl than helicopters. Alternatively, Kushlan (1979) found no difference between the two types of aircraft on egret and heron colonies and that these species appeared to be relatively undisturbed by aircraft. Yet, Owens (1977) reports that wintering brant geese were highly disturbed by helicopters and low flying airplanes. These disturbances caused geese to reduce their feeding times and increase flight durations. Clearly, species may vary in their tolerance to aircraft disturbances and may be more sensitive during certain seasons than during others.

Studies of General Applicability to the Overthrust Belt

Unfortunately, there is no comprehensive information on the composition, distribution, abundance or population ecology of the area's game birds. Dorn (1978) summarized the limited historical avian information for the Overthrust area. The Environmental Assessment for the Kemmerer Resource Area (USDI Bureau of Land Management 1979) summarizes limited information from the literature on the kind and size of habitat occupied, general population trends, and 1976 harvest data for sage grouse, blue grouse, ruffed grouse, chukar partridge, gray partridge, mourning dove, and the collective term "waterfowl." A summary of species composition, geographic and seasonal distribution, abundance and habitat preferences for Wyoming birds is presented by Oakleaf et al. (1982). Annual waterfowl breeding surveys are conducted by the Wyoming Game and Fish Department on the Bear River, Greys River, Salt River, and Snake River, primarily for Canada goose management. Summaries of some of these data are provided by Appel (1971), Saul (1971), Bone (1973) and Dimmick (1968) for the Bear River and the Snake River. A broad update of these data and discussion of changes affecting waterfowl and wetland game birds is scheduled for a Federal Aid to Wildlife Final Completion report due in March, 1983 (Lockman, Wyoming Game and Fish Department, personal communication).

Several projects in areas peripheral to the Overthrust Belt contain game bird information which may have baseline application. Burleigh (1972) Behle and Ghiselin (1958) and Behle and Perry (1975) species occurrence and distribution records along the Wyoming, Idaho, and Utah state lines are relevant. To the east of the Overthrust Belt, the White and Behle (1960) study of the Flaming Gorge upland and riparian areas scheduled for flooding when that dam was completed is one of the most complete detailed investigations of riparian and upland avifauna in Western Wyoming. June (1963) summarizes sage grouse population data for the Farson-Eden area of Sweetwater County for the period of 1949-62. On a broader scale, the Biosystems (1981) study provided similar detail along with density estimates, measures of bird species richness, avian diversity, and distribution in 16 habitat types. Huchabee's (1965) study of waterfowl breeding in the willow wetlands of Grand Teton National Park provides insight to the duck species one might encounter in the mid-montane areas of the Overthrust Belt.

Harju's (1974) study of blue grouse in the Medicine Bow Mountains represents the only in-depth study of that species in Wyoming. While Patterson's (1952) study of sage grouse in Wyoming is frequently referred to, it lacks sufficient data on the Overthrust Belt. For current general species and ecological information Bumb et al. (1947), Johnsgard (1973), Rothenmaier (1979), and Dalke et al. (1963) are useful. Also, useful general and ecological information on ruffed grouse, chukar, and gray partridge can be found in Johnsgard (1973) and Mussehl (1963). Basic biology, ecology, and management of the mourning dove can be found in Keeler (1977) and Johnsgard (1975a). Basic information on the biology of the sandhill crane is available from the studies of Lewis (1977) and Johnsgard (1975a). Similar information on the American coot can be obtained from Frederickson (1977) and Johnsgard (1975b). In the absence of specific Wyoming investigations of waterfowl in the Overthrust Belt, basic biology, migration and management data on ducks and geese can be found in Bellrose (1980) and Johnsgard (1975a). Lastly, general ecological and management information on the common snipe can be found in Fogarty and Arnold (1977) and Johnsgard (1975a).

Summary of Literature Review

According to the literature, oil and gas development has the potential to impact game bird species in a variety of ways. Terrestrial species, such as grouse, are subject to habitat losses resulting from road and drill pad construction. These losses may be significant on local populations if traditional breeding grounds are included. Efforts by mining companies to relocate leks have been marginally successful. Furthermore, noise associated with development activities may affect breeding activities. Both terrestrial and aquatic game birds are affected by powerlines that commonly accompany industrial development.

Waterfowl are particularly vulnerable, according to the data, to contaminated waters produced by oil spills and reserve ponds during the drilling process. The literature indicates that petroleum products and byproducts are

toxic to waterfowl, decrease thermal insulation of contaminated feathers, and decrease reproduction and survival of young.

As with other wildlife species, game birds demonstrate a variety of responses to disturbances from aircraft; the variation may be attributed to species differences and differences by seasons and stages of the life cycle.

Summary of Data Gaps

The diversity of habitat requirements and residency status for game birds in the Overthrust Belt makes generalizations difficult. But very little documentation is available which clearly shows decreased nesting success by either terrestrial or aquatic species as a function of human disturbance. Where such studies have been conducted, they were plagued by limited time durations and did not examine contributions by other environmental variables such as weather, habitat quality, and predation. Indeed, the effects of nest predation on game bird species has been suggested to increase with increasing human disturbance, in general and to specific nests, but has not been verified in any of the studies included in this review.

Oil as a pollutant has been documented; however, there are few reports on the impact of oil pollution in snowmelt runoff and in sediments carried by these waters. Detailed documentation of the secondary pollutant impact on wildlife habitat is also missing with respect to pollutants in vegetation, sediments, and turbidity in streams.

Critical comprehensive baseline data on game bird species composition, numbers, seasonal distribution and habitat use are not available for the Overthrust Belt. The use of optimal vs. non-optimal habitat by upland game birds and wetland habitat by waterfowl has not been documented. Without this information predictive models useful in future impact assessments cannot be formulated. However, the need for and costs of such data and models must be carefully evaluated.

NONGAME WILDLIFE

Introduction

Nongame wildlife includes all species of animals that are not used for consumptive purposes and, therefore, includes the vast majority of wildlife species. This group, however, has not been subjected to extensive studies or management. As a result, lack of information on nongame wildlife has resulted in species shifts that are considered undesirable. Changes such as predator removal, urbanization, and other human-directed alteration of the environment have resulted in population imbalances of one or several nongame species.

There is a large group of people who are quite interested in simply looking at wildlife. Nongame species compose the greatest component of wildlife and are of great interest to these people. Changes in the attitudes of American people are pointed out by Kellert (1980). This report prepared under con-

tract by the U.S. Fish and Wildlife Service shows that in 1970, 4.4 percent of the population in the United States made special trips to watch wildlife. In 1975, 27 percent of the population engaged in such activities. In Idaho, 60 percent of the residents made such trips. This fact is very important to organizations involved in land development or land-use changes. The results can be positive impacts both for the corporation and the whole community.

Nongame wildlife species are important not only for their aesthetic and recreational values (Kellert 1980), but for the interrelationships that have evolved as primary and secondary consumers in maintaining community balance (Peterson 1980, Maser et al. 1978).

Literature Overview

Compared to other wildlife groups, information on the impacts of resource development on nongame species are scanty, especially when the diversity of this group is considered. Brink (1978) has studied the effects of the Trans-Alaskan pipeline haul road on small mammals and nongame birds and Barry and Spencer (1976) examined nesting success in relation to an operating oil well in the Canadian arctic. Elsewhere, Flickinger (1981) reported on wildlife mortalities in Texas sludge pits.

Other studies have approached various habitat modifications, such as logging, fire, road construction, grazing and right-of-way clearing for transmission lines, by investigating species changes in the affected nongame community (Hager 1960, Webb et al. 1977, Markel and Radvanyi 1977, West et al. 1980, Nelson and Peak 1981, Oxley et al. 1974, Anderson et al. 1977). Species changes in riparian habitats due to livestock grazing (Johnson 1982, Reynolds and Trost 1981), in habitats along disturbed roadside areas (Oxley et al. 1974, Michael 1975, Wilkins and Schmidly 1980), and in clearings produced by transmission lines corridors (Anderson 1979, Anderson et al. 1977), logging (Hager 1960, Webb et al. 1977, Markel and Radvanyi 1977, West et al. 1980), and fire (Blake 1982) are well documented and may be expected to occur in disturbed habitats brought about by oil and gas development (PRISM 1982). Attention has been drawn to changes in the physical characteristics of nongame habitats as they influence community diversity and the abundance of member species (MacArthur 1959, Thomas et al. 1979, Anderson and Shugart 1974, Anderson and Robbins 1981) and knowledge of these relationships can be used in nongame wildlife management programs (Thomas et al. 1979, Anderson 1980, DeGraaf and Tigman 1980, Graber and Graber 1976).

More immediate effects of development on nongame species can be expected to occur along roads where vehicle emissions contaminate soils and vegetation (Milberg et al. 1980, Motto et al. 1970, Gish and Christensen 1973) and lead uptake by small mammals and invertebrates is documented (Goldsmith and Scanlon 1977, Jefferies and French 1972, Quarles et al. 1974, Getz et al. 1974). Transmission lines are sources of avian mortality for nongame birds (Nelson 1978, Oak Ridge Associated University 1978).

Studies of the Effects of Resource Development on Nongame Wildlife

Oil and Gas Industry. Few studies causally demonstrate the impact of oil and gas development on nongame wildlife. The impact of oil and gas development does not cause a unique type of habitat disturbance but acts to reduce size, change structure, or increase human impact, all of which alter the nongame community. This is brought out in the review published by the Canadian Petroleum Society which reviews the petroleum industry operation and land-use activities that affect wildlife (PRISM 1982). One of the major findings was that petroleum industry activity increases public access. Seismic lines and pipelines create temporary access routes, while roads create permanent access to new areas. Traveling on roads, hunting, and other public use result in a change in habitat and a shift in wildlife populations. The study points out that the single most important way oil and gas development affects wildlife is through roadway construction. In a field study on the Trans-Alaskan oil pipeline, Brink (1978) found that birds and small mammals adapted behaviorally to pipeline structures. The major adverse effects were habitat loss and alteration and disturbance resulting from increased predation and barriers. She mentioned human impacts of pipeline construction and consequent shifts in populations. Some studies show that wildlife species, particularly nongame, are attracted to petroleum pits. In Texas, about 30 percent of the open oil field spillage pits contained dead waterfowl, shore birds and some passerines (Flickinger 1981). In a study of the effects of oil well drilling sites in Canada, Barry and Spencer (1976) showed that populations shifted, some predators became more active, and other species adapted to changes. The changes again involved an alteration of habitat size, structure and human activity.

Timber Harvest, Grazing and Other Land Uses. Logging and clear-cutting as well as scraping of land have a major impact on nongame communities by changing habitat structure. There is a great deal of documentation in the literature on the changes in bird and mammal communities as a result of logging, fire, or other habitat destruction (Hager 1960, Webb et al. 1977, Markel and Radvanyi 1977, Blake 1982). For example, field studies show the northern redback voles respond to change by leaving clearcut forests (West et al. 1980). Removal of forest reduces all cavity-nesting birds. However, there is virtually no literature that is specific to the Overthrust Belt. These and other publications, in effect, show how major changes in community structure and size shift the populations of nongame communities and destroy the ecological balance that existed. Again, this type of disturbance can be avoided by leaving some of the natural community.

Grazing has an impact on the type of nongame community (Nelson and Peak 1981). This is particularly true where grazing occurs in riparian zones and in unique habitats (Johnson 1982, Reynolds and Trost 1981). In a study currently underway at the University of Wyoming, biologists are finding that alteration of community structure changes animal species composition.

Roadway Construction and Transmission Lines. Habitat alteration due to roadway construction and transmission-line corridors, reduce habitat size and

establish new types of habitat. Several papers review the effects of roadways on small mammals (Oxley et al. 1974, Michael 1975, Wilkins and Schmidly 1980). These studies show that roadway construction creates edge habitat along roads which attracts species that have less specific needs. In some cases, roadways serve as barriers to movement of small mammals while in other cases they cause excessive mortality. A variety of studies on the increase in lead concentrations of soils, vegetation, and small mammals near highways are found in the literature (Quarles et al. 1974, Goldsmith and Scanlon 1977, Getz et al. 1974, Milberg et al. 1980, Mott et al. 1970, Gish and Christensen 1973).

Transmission lines and pipeline corridors serve to subdivide the habitat in the same manner as roadways, thus it is important to know the total size of habitat required to maintain a nongame community before corridor construction occurs. Corridors create a new community of grassland between adjacent habitats. This is a pronounced problem in shrub and forest communities. A field study in an eastern deciduous forest (Anderson 1979) found that in a transmission corridor virtually all migratory birds disappeared while edge and grassland species became established in the area. Anderson et al. (1977) showed that transmission-line corridors in an eastern deciduous forest less than 30.5 m wide did not have a significant effect on the bird community of the whole forested area. Schreiber and Graves (1976) indicate that transmission line corridors are a barrier to movement of nongame species, particularly small mammals. Small mammal populations are more likely to be eaten by predators as they cross these areas and some species will not cross at all.

A study by Nelson (1978) indicates that transmission lines are known to be a source of mortality for migratory birds (Nelson 1978). Specific data on the construction of transmission-line corridor towers should be sought, particularly in forested areas (Oak Ridge Associated University 1978). Transmission lines do, however, serve as perch and nest sites for some species of birds, particularly raptors. (See discussion in section on raptors.)

Nongame species play important roles in communities through the process of energy movement in a natural system, nongame species feed on plants and other animals. If a pesticide program is initiated in which many insects are killed in an area, the impact will be pronounced on both birds and small mammals. This fact shows the community balance that nongame maintain since birds and small mammals assist in keeping insect populations at a level below which they can cause economic damage (Peterson 1980). Birds directly affect western communities through consumption of seeds. Seed dispersal can be enhanced by birds ingesting seeds and depositing them in open areas or along fence rows and power lines. Maser et al. (1978) indicated the importance of small mammals in transporting fungal spores into clear-cut areas. Coniferous trees in Oregon forests were found to have an obligatory symbiotic relationship with fungi. It was necessary to have fungi presence in order to establish tree species in clearcut areas. Small mammals ingested fungi spores, carried them into the open areas and deposited them in their droppings; therefore, they enhanced the establishment of coniferous forests. This classic paper points out important interrelationships that exist between nongame wild-

life species and the community. The former idea of poisoning forest rodents to enhance tree survival is the reverse of what needs to be considered.

Major community changes that the literature indicates affect nongame communities include changes in community size, changes in structure which involves a change in successional sere, alteration of moisture, and disturbance of unique habitat features such as riparian zones. A number of studies underway and reported in the literature indicate that habitat size is important to bird communities (Anderson and Robbins 1981, Thomas et al. 1979). There is other evidence to show that small mammal communities rely on the size of the habitat. In the eastern deciduous forest, Robbins (1979) found that fragmentation of a contiguous forest from a single 5,260-hectare unit to a number of 40-hectare units over 25 years resulted in a change in bird species. In this study, nine species of long-distance migrants disappeared from the breeding population of the study sites. This study showed a positive correlation between contiguous forest area and the number of migratory birds found breeding in the area. A study by Anderson and Robbins (1981) described the importance of understanding the size of communities in different parts of the country, using field data from Maryland, Michigan, and Oregon. Thomas et al. (1979) felt that 34 hectares was sufficient area in the Blue Mountains of Oregon to maintain nongame communities. In western Maryland, areas greater than 1,300 hectares were required to support the full complement support the full complement of breeding bird communities. The differences in these studies are due to differences in the forest communities in the regions. The highly migratory bird community in the eastern deciduous forest requires much larger tracts of land than areas in the western part of the county where a high proportion of the bird species are non-migratory (MacArthur 1959). All of these studies on habitat size are reliable. They indicate the importance of knowing size of habitat that supports different nongame communities in the Overthrust Belt.

Habitat structure appears particularly important when looking at nongame communities. Thus, brush clearing, burning understory vegetation, and increasing grazing pressure all impact on the structure of the community and alter the wildlife species present. Edge or the area between two habitats has structure that is different from the surrounding community and supports different species (Thomas et al. 1979). Anderson and Shugart (1974) used extensive field data to show how direct correlations are measured between breeding birds and structural components in an eastern deciduous forest. This study pointed out the need to understand both features of the habitat, as well as layering within the habitat. Different nongame species use each layer and occupy different microclimates within the habitat. Structure was listed as one of the most important habitat factors when looking at means of managing nongame communities in different successional seres (Anderson 1980).

Studies of General Applicability to the Overthrust Belt

The number of nongame wildlife studies that have been conducted in the Overthrust Belt is limited. Management of nongame is management of habitat to maintain the community of wildlife. This involves habitat sampling, popula-

tion sampling and statistical analysis that show particular characteristics of the community important to the various wildlife species present.

Several review books are useful references on standard techniques for sampling nongame populations and communities. These include publications on birds (Ralph and Scott 1981) as well as census methods for terrestrial vertebrates and their habitat (Davis 1982).

Maser et al. (1979) discusses different aspects of habitat that are used by different organisms in the Great Basin of southwestern Oregon. They indicate features including ledges, slab rock, and shallow caves which are used by bats, raptors, small mammals and reptiles. Their publication points out that each component of a habitat is a unique feature attractive to certain species of wildlife.

Within any community there are often unique habitats. In western Wyoming this is particularly true with the small areas of cottonwood, willow, and grasses around waterways (riparian habitat). These areas support an abundance of wildlife species (Olson and Gerhart 1982). Tubbs (1980) discusses the value of riparian habitats to wildlife and shows that over 136 bird species use these areas. A number of breeding birds are restricted to riparian vegetation and outnumber the many species found in nearby grasslands (Stevens et al. 1977). Some small mammal species have been found susceptible to riparian habitat alteration (Geier and Best 1980). Riparian communities are, therefore, unique habitats that are important in arid and semiarid environments, particularly in western Wyoming (Olson and Gerhart 1982).

In 1980, the US Forest Service published a workshop proceedings on management of western forests and grasslands for nongame birds (DeGraaf and Tigman 1980). This publication summarizes a considerable volume of valuable field data that is applicable to the area for management of nongame birds. Papers that relate to bird communities in the Overthrust region include studies on the effect of sagebrush communities (Braun et al. 1976) and evaluation of habitat change in a Utah marsh on bird populations (Weller et al. 1958). A study by Salt (1957) of the avifauna in the Jackson Hole area is applicable and studies in Colorado by Gaul (1975) on the mountain plover and Bottorff (1974) on cottonwood are useful. Behle and Ghselin (1958) prepared a paper on birds of the Uinta Mountains and basin of northeastern Utah. Oakleaf et al. (1982) have published the Wyoming Avian Atlas that indicates what birds are present in areas on a seasonal basis, while Johnson (1975) produced a paper on bird species of montane islands in the Great Basin.

Papers on small mammals are uncommon for the area. Mammals present in Wyoming are shown in the Wyoming Mammal Atlas (Findholt et al. 1981) and Long's (1965) reference work. Studies on changes in juniper grassland are found for some western areas of the United States and are directly applicable to mammals in the Overthrust Belt (Robinson 1966, Baker and Frischknecht 1973). Sagebrush associations of small mammals are documented in a paper by Larrison and Johnson (1973).

Some biologists believe that indicator species can be used to judge habitat quality and habitat change (Graber and Graber 1976). The overall concept of using indicator species has not been well received because of the difficulty in relating species to each habitat type.

Summary of Literature Review

According to the literature, direct mortality of nongame species during human development in wildlife habitat is likely to occur. Causes for nongame mortality are diverse but not quantitatively documented. Nevertheless, the impact of oil and gas development on nongame wildlife appears to be primarily habitat alteration. Changing the habitat structure, subdividing the habitat and bringing more people into the region can all act to change the nongame community. The effects of these impacts on nongame birds in the Overthrust Belt are not known.

Summary of Data Gaps

While it would be difficult to say that work is needed on all forms of nongame birds in the Overthrust Belt, the lack of information is apparent. Therefore, it is important that selective surveys be made in the different habitat types. These data could indicate types of wildlife present and unique features of the habitat. The data could then be added to the Wyoming Wildlife Observation System or other data systems that are available. The most important research need for the Overthrust Belt is to develop an understanding of the size of the habitat necessary to support different nongame communities found in an area. Unique features of an area, such as riparian habitat, aspen communities, and small islands, or particularly structural components of the habitats such as outcrops or dead trees, could be evaluated. This would assist developers in planning construction and placement of facilities. Particular features of the habitat could be evaluated to aid in reclamation.

REPTILES AND AMPHIBIANS

Introduction

Knowledge of reptiles and amphibians occurring in the Overthrust Belt is limited (see Task 3 - Local Knowledge). Resident amphibian species in the Overthrust Belt include two morphological types of the ubiquitous tiger salamander (normal terrestrial and neotenus), the great basin spadefoot toad, boreal toad, leopard frog, spotted frog, and the boreal chorus frog. Of these, the spotted frog resides in the northern section of the Overthrust Belt south to Star Valley and east to the Wind River mountains. No amphibian species are listed as endangered or threatened, although it is possible that a relic population of woodfrogs may exist in the area.

Two lizard species, the eastern short-horned lizard and the northern sagebrush lizard are widely distributed in Wyoming's Overthrust Belt. Two other species of lizards are limited to the Green River drainage on the

Wyoming-Colorado border, the northern plateau lizard and the northern tree lizard (Baxter and Stone 1980). Only one species of snake, the wandering garter snake, is common in the area. Other snake species are likely to occur in isolated areas (Baxter and Stone 1980). The rubber boa, bullsnake, and common garter snake are found in northwestern Wyoming and eastern Idaho and the midget faded rattlesnake, western smooth green snake, and Great Basin gopher snake are limited to the Green River area of southern Wyoming. The Wyoming Game and Fish Department (1977) considers the rubber boa and western smooth green snake rare in Wyoming. Amphibians are dependent on aquatic and riparian areas, while reptiles in the area occupy desert shrub and riparian habitats.

Literature Overview

Although well-studied in other North American, desert/shrub arid zone habitats, reptiles in the Overthrust Belt are less well-known. Numerous studies have been conducted in the arid zones of California (e.g., see Bury (1980, Bury 1982a, Bury et al. 1977, Bury et al. 1980, Busack and Bury 1974, Carter 1974, Vollmer et al. 1976, Wilshire and Nakata 1976). All of these studies show how habitat alterations affect reptile populations. Effective management plans have been developed (Bury 1980, Flickinger 1981, Vollmer et al. 1976, cf. Dodd 1977).

No studies were found that investigated oil and gas impacts on this species group with the exception of Flickinger's (1981) report of amphibian mortalities in petroleum sludge pits. Both amphibians and reptiles are likely to be impacted by changes in water quality (Saber and Dunson 1978).

Studies of the Effects of Resource Development on Reptiles and Amphibians

Oil and Gas Industry. Information about the effects of oil and gas development on reptiles and amphibians is limited. No reports concerning the effects of crude oil, reserve pit fluids, or other material associated with drilling operations were found. A single reference outlining the number of amphibian mortalities in open petroleum pits (structures not likely to be built in the Overthrust Belt) is available (Flickinger 1981).

Roads and Recreational Activities. Virtually any human activity that affects soil surface characteristics (Wilshire and Nakata 1976), vegetation (Busack and Bury 1974, Jones 1981), riparian or pond biology, or water quality (Dodd 1977) can affect lizards and snakes.

Several years of detailed work by Bury and his coworkers, and by the California Department of Fish and Game have demonstrated an inverse association between increased intensity and frequency of off-road vehicle (ORV) activity in the Mojave Desert and decreased reptile and small mammal biomass, species diversity, total numbers of individuals, and density (Bury et al. 1977). Bury (1980) and Carter (1974) have conducted studies indicating that if ORV activity is left uncontrolled, or is frequent or intense, entire vegetation regimes and small mammal and reptile populations can be destroyed. As

Wilshire and Nakata (1976) note, extreme ORV use in arid zones can induce surface geological damage that can require thousands of years of natural recovery. This was the effect of just one of the famous "Barstow to Vegas" motocross races of early 1970s (Wilshire and Nakata 1976). Fortunately, detailed studies (Vollmer et al. 1976) indicate that low intensity and infrequent ORV activity or confinement of driving to newly constructed and maintained dirt roadways in arid zones will not drastically reduce diversity and density. If driving patterns of the latter type are used, shrub damage can be controlled. Therefore, as long as exploration, seismic, and construction crews do not drive intensely or rapidly (Vollmer et al. 1976) in undisturbed arid zone habitat in the Overthrust Belt, habitat and small vertebrates would not be damaged or threatened. Once all phases of construction are complete and established gravel roads in place, all forms of habitat and wildlife damage could be reduced if ORV activity was minimized (Vollmer et al. 1976).

A report by Wilkins and Schmidly (1980) indicates that large numbers of all vertebrate taxa are killed on even slightly used highways (Kozel 1977). In the case of reptiles, such deaths peak in the spring. Since reptiles are ectotherms, this is particularly the case because these animals prefer to lay on paved highways to absorb heat at dawn and dusk hours, and during the night (Stebbins 1966). Gravel roadways do not attract large numbers of lizards.

Research results do not clearly show the effects of construction noise on reptiles (Brewer 1974, Fletcher and Busnel 1978).

Studies of General Applicability to the Overthrust Belt

In many respects, arid zone, shrub communities of the tri-state Overthrust Belt region are very similar to those of California's Mojave Desert. Both communities are dominated by desert shrubs. Reptiles are rather uniformly distributed in both regions (see Bury 1982b). This discussion considers the roles of lizards and snakes in arid zones (e.g., see Bauerle 1975, Busack and Bury 1974).

Most lizards lay eggs in moist sand of small rivers, creeks, and washes (Duvall, unpublished data, Fitch 1940, Mautz 1982). Physical and chemical changes in the water can influence reproduction.

Although many areas of the Overthrust Belt contain no rattlesnakes (Baxter and Stone 1980, Hammerson 1982, Stebbins 1966), some populations may border or reside in developed regions. These animals would not complicate development as long as their migratory pathways and den locales are known. Simply, one would not want to center human activity in these places, as it is virtually impossible to eliminate rattlesnakes with any of the commonly practiced methods (Duvall, unpublished data). If a drilling pad was constructed in a seasonal rattlesnake migratory pathway, it would be inundated by adult males on foraging migrations (Duvall and King, in preparation). If dens and migratory pathways are located during the exploration phase of energy develop-

ment no problems with venomous reptiles should arise (Duvall, unpublished data).

Although many methods exist for studying reptile populations (Campbell and Christman 1982), the removal method appears best (Bury 1981 and 1982b, Zippin 1956). This is a rapid, accurate, and repeatable method of population and community analysis for populations of small animals in habitats with uniformly distributed flora and fauna (Zippin 1956). Bury (1981) has argued convincingly that arid zone reptile communities and vegetation are distributed in this way, and that all other critical assumptions that predicate the use of this sampling technique hold as well. Duval (unpublished data) has used this method successfully in estimating size of populations of Wyoming and California reptiles.

Acid rain is considered by most herpetologists to be the chief factor in the decline observed in amphibian populations in the northeastern United States (Saber and Dunson 1978). Of special concern would be the potential harm to two endemic species of anurans. The effects due to inorganic and organic constituents would be the same as those expected for fish. The streams in most of the Overthrust region are alkaline and have intermediate to high buffering capacity. Consequently, increased acidity due to acid precipitation would have little effect. However, in the granitic mountain ranges (Wyoming Range, Wind River Range, Snowy Range, or Uinta Range) where there is little buffering capacity of the waters, acid precipitation could have considerable deleterious effects.

The overall effects of water quality changes on fish would be similar for the permanently aquatic amphibians (leopard frog, spotted frog, and neotenic tiger salamanders) and all larval amphibians. Therefore increased temperature, decreased dissolved oxygen, increased suspended solids, or altered pH would harm amphibian populations. (See FISH, below.)

Summary of Literature Review

Practically nothing is known of the effects of oil and gas development on amphibians and reptiles. Amphibians are susceptible to oil contaminated reserve pits, but the effects of petroleum discharges into aquatic habitats have not been reported. Known impacts caused by vehicles traveling through open country on reptiles have been documented in the southwestern United States. Low intensity off-road vehicle use in arid ecosystems is not likely to impact herpetofauna and vegetation as much as frequent off-road vehicle travel. Reptiles are potentially vulnerable to paved highways during dawn, dusk, and spring migration periods.

Summary of Data Gaps

With the near absence of information on resource development effects on reptiles and amphibians there is much to be learned. Impacts on amphibians are expected to result primarily from alteration of aquatic and wetland habitats. However, tolerances of different amphibian species and life stages to

siltation and petroleum-related contamination are unknown. Likewise, tolerance of reptiles to activities associated with the oil and gas industry are unknown. No information is currently available which could be used to determine where roads would impact reptiles. Consequently, the lack of species distributional data should probably be addressed. What species are present, where are they found, and what unique features of the habitat support them (habitat quality) should be summarized. Recommendations for avoiding habitat impacts could then be made. Species present in unique habitats or with limited tolerances could be used as indicators of habitat quality.

FISH AND AQUATIC RESOURCES

Introduction

All wildlife are affected by the quality of available water. While many birds and terrestrial animals use water primarily for drinking (e.g., deer, grouse, lizards), others live in water a considerable amount of time (e.g., beaver, ducks, salamanders). And of course, aquatic animals spend most or all of their lives in water (e.g., frogs, stoneflies, fish). Since aquatic animals cannot avoid adverse water quality changes as easily as can terrestrial and semi-aquatic animals, aquatic animals are often the most directly affected wildlife group during periods of intense or heavy development.

In this section, potential effects on fish populations are considered in terms of effects on aquatic ecosystems and closely associated riparian zones. The effects of any development on the aquatic environment can be categorized broadly as: 1) physical habitat impacts (e.g. water flow, substrate); 2) chemical habitat effects (e.g. water quality); or 3) resource use impacts (e.g. fishing pressure). The only effect unique to oil and gas development results from alterations to water quality. In the literature, potential effects are addressed in these terms. Fish are biological components of aquatic ecosystems which are highly valued by humans and are easily understood by the non-biologist. As such, fish are the principal component of the aquatic environment discussed in this section.

Literature Overview

Recently, the potential for oil and gas development effects on fish and other aquatic organisms has been addressed generally by several investigators. Primarily, these possible impacts stem from contamination of surface and ground waters. The Environmental Protection Agency (EPA) provides information on toxic effects of chemicals used in drilling muds, well fluids, and chemical additives (EPA 1975). Weir and Moore (1975) and Woodward (personal communication) have documented toxicities of mud pit and reserve pit fluid components on fish and other aquatic organisms. Natural concentrations of inorganic compounds in western Wyoming waters are fairly high, contributing to intermediate to high hardness, alkalinity, and conductivity levels (CH2M Hill Inc. 1978, Miller 1977, Remmick 1981). The combined effect of relatively high inorganic levels and industry-related inorganic compounds on fish survival is unknown, although the effects of inorganic pollutants on aquatic organisms

have been reported by EPA (1976), Sorenson et al. (1977), U.S. Council on Environmental Quality (1978), and Thurston et al. (1979).

Water soluble components of crude oils are known to be toxic to fish (Whitman et al. 1982). Woodward et al. (1981) have shown toxicity of Wyoming crude oil to cutthroat trout, while Woodward and Riley (in press) provide similar documentation for the effects of oil field discharge. Refined oil also contains toxic elements (Woodward et al., in press). Chemicals used to control oil spills can also be toxic to fish. Rehwooldt et al. (1974) reported that ionic dispersants are more toxic to aquatic organisms than crude oils. Crude oil also affects food organisms used by fish and can lead to deterioration of aquatic food chains (Federle et al. 1979, Rosenberg and Snow 1975, Rosenberg and Wiens 1976, Rosenberg et al. 1977, Rosenberg et al. 1980).

Atmospheric discharges of sulfur and nitrogen oxides from gas sweetening plants may lead to acidification of surface waters. EPA (1976), Katz et al. (1979), Spry et al. (1981), and Western Aquatics Inc. (1982) present information on the known effects of increased acidity on aquatic biota. However, because of the intermediate to high buffering capacity of waters in the Overthrust Belt (CH2M Hill Inc. 1978, Miller 1977, Remmick 1981) acidification is not expected to be a major water quality problem.

Water quality problems are known to occur through other land uses including road construction, logging, grazing, channel manipulation and recreation. Where these practices remove or destroy riparian vegetation, erosion of soils and resultant sedimentation decrease water quality and adversely affect fish populations (Aitken 1936, Ellis 1936, Cordone and Kelley 1961, Copeland 1969, Gebhardt 1970, Hollis et al. 1964, Ritchie 1972, Saunders and Smith 1965). Sedimentation and turbidity in streams can influence water temperatures (Brown and Krygier 1967, Lantz 1971, Burns 1972, Patton 1973, Ringler and Mall 1975, Sharpe 1975). Increases in water temperature can lead to decreased dissolved oxygen, thereby adversely affecting fish (Hoss et al. 1979, Katz et al. 1979). Loss of streamside vegetation cover through livestock grazing and trampling produces similar deterioration of water quality (Crumpacker 1981, Benson 1979, Warner 1979, Schmidly and Ditton 1978, Behnke and Raleigh 1978, Armour 1977, Carothers 1977). Likewise, the use of recreational vehicles can destroy riparian vegetation and increase erosion (Heede 1976, Settergren 1977, Miller 1979, Johnson and Carothers 1980).

Roads crossing streams can affect fish passage and migration (Bachman 1958, Anderson and James 1957, Anderson and Bryant 1980) as well as increase stream sedimentation (Megahan and Kidd 1972, Burns 1970, 1972). Erman et al. (1977) discussed streamside buffer strips to reduce sedimentation and procedures to reduce impacts on streams from logging have been specified (Society of American Foresters 1959, Haupt and Kidd 1965). Additionally, Dryden and Stein (1975) and Hynson et al. (1982) have recommended mitigation measures to reduce the impacts of road construction on fisheries and aquatic resources.

Resource development of any type is expected to lead to increased human populations and, in turn, to increased fishing pressures on available fish

populations. Behnke (1976), Binns (1977) and Quinlan (1980) have reported on susceptibility of native cutthroat trout to fishing. Specifically, local cutthroat trout populations may be severely impacted by recreational fishing.

Studies Regarding Effects of Resource Developments on Fish

Oil and Gas Industry. Little published literature specifically addresses the impacts of oil and gas development on aquatic environments in the Overthrust Belt. Since the Overthrust Belt contains few reservoirs and other lentic habitats, most of the following discussion reviews potential effects on fish communities of stream habitats.

Most of the literature on the physical aspects of aquatic habitats comes from studies of livestock grazing, road construction, logging, recreation, and streamflow alteration and channelization. Specific impacts of the various uses are discussed below as they relate to aspects of oil and gas development. Unique impacts can arise from changes in water quality including: (1) potential release of drilling muds and reserve pit fluids to surface water, (2) potential spills of crude oil and other hydrocarbons; and (3) the possibility of acidifying deposition downwind from gas sweetening plants.

Reserve pit and well fluids, drilling muds, and chemical additives can contain components such as barite, calcite, siderite, bentonite, phosphates, tannins, lignites, lignosulfonates, pipe dope, etc. (EPA 1975). These constituents are known to be toxic to fish and aquatic biota (Weir and Moore 1975). In particular, chromium, zinc, asphalt, vinyl acetate polymer, diesel oil, filming amine, ethoxylated nonyl phenol, parformaldehyde, tall oil, etc. have been associated with drilling (EPA 1975). The EPA (1975) manual presents detailed information on the toxic effects of chemicals. In one study (Woodward et al., in press), investigators reported cadmium, chromium, copper, lead and zinc in the aqueous discharge from a Wyoming oil field. There is potential for both organic and inorganic contamination of aquatic resources during oil and gas development. Yet, the relative importance of these chemicals will vary considerably between drainages, as will the effects of individual compounds on aquatic biota. Effects of the inorganic pollutants on aquatic organisms have been reviewed extensively (EPA 1976, Sorenson et al. 1977, U.S. Council on Environmental Quality 1978, Thurston et al. 1979). However, complete toxicity characteristics are not known for all inorganic constituents identified in the fluids associated with drilling. Although many high-molecular weight organic compounds in drilling muds are relatively non-toxic (Zitko 1975), lower-molecular-weight additives are acutely toxic to aquatic biota. The extent of this problem is not clear.

In general, major ion concentrations are high throughout Wyoming's Overthrust Belt. For example, Miller (1977) reported no streams, rivers, or standing waters in the Bear River drainage that had hardness values less than 100 mg/L as CaCO_3 . Additionally, no conductivity values less than 130 umhos/cm and only one alkaliity value of less than 100 mg/L as CaCO_3 occurred. In the Green River westside tributaries, Remmick (1981) reported hardness values of less than 100 mg/L for several Montana streams and reser-

voirs. Alkalinity and conductivity values were correspondingly low. However, the majority of streams, rivers and standing waters in Green River westside drainages contain intermediate to high hardness, alkalinity and conductivity levels (Remmick 1981).

In a recent test of a reserve pit fluid in Wyoming, chemical analyses of the conventional pollutants (pH, conductivity, major ions, etc.) and two heavy metals (zinc and chromium) indicated acceptable concentrations for all parameters. However, cutthroat trout died after 12 minutes in this water (Woodward, personal communication). Weir and Moore (1975) reported similar results for drilling muds used in the Canadian arctic.

The potential for oil field discharges and oil sump leakage into aquatic habitat is documented in Wyoming in three studies (Millis 1969 and 1972, Mueller 1968). Since the organic compositions of surface waters in the Overthrust Belt have not been analyzed, baseline organic pollutant levels currently cannot be defined. Potential organic pollutants, however, may arise from oil and gas developments.

Organic collectors and dispersants are sometimes used to control oil spills. These chemicals are intentionally released into a water body containing an oil spill based on cleanup decisions by oil companies and state and federal authorities. Although not all oil dispersants and collectors have been tested, the available data indicate that ionic dispersants are much more toxic to aquatic biota than crude oils (Rehwooldt et al. 1974). In addition, because they increase the solubility of oil components, these dispersants may increase the toxicity of the spilled oil. Collecting agents appear to be much less toxic than dispersants and probably contribute little to the toxicity of a treated oil (Rehwooldt et al. 1974).

Considerable spills research has been conducted concerning the effects of water soluble components of crude oils on fish (Whitman et al. 1982). This research indicates that acute toxicity is a primary concern during oil and fuel spills, and that for prolonged exposures, sublethal effects such as reproductive impairment, osmoregulatory stress, bioaccumulation, and predatory and avoidance behavior may be more important. The literature also indicates that changes in the food chain such as use of alternate pathways can also occur (Federle et al. 1979, Mozley 1978, Rosenberg and Snow 1975, Rosenberg and Wiens 1976, Rosenberg et al. 1979 and 1980).

Usually, the acute toxicity of water soluble fractions of crude oil is low according to the literature. This probably explains why no fish mortalities were observed for a major oil spill on the Shoshone River in Wyoming during August 1982 (Stone, Wyoming Game and Fish Department, personal communication).

Several studies indicate that oil spills can adversely affect aquatic organisms. For example, Woodward et al. (1981) reported a 96-hour LC50 (median lethal concentration) of 2.4 mg/L for cutthroat trout exposed to a Wyoming crude oil. Furthermore, Woodward et al. (1981) determined a threshold

effect of approximately 100 mg/L for 90-day exposures, based on reduced growth of cutthroat fry. Studies of a Wyoming refined oil (Woodward et al., in press) and a Wyoming oil field discharge (Woodward and Riley, in press) support Woodward's conclusion.

According to the literature, zooplankton and aquatic macroinvertebrates respond both positively and negatively to crude oil spills. For example, oil perturbation caused a decrease of zooplankton populations and a reduction of primary production in only three to four days in arctic tundra thaw ponds (Federle et al. 1979). But in the same experimental spills, oil killed macroinvertebrates only in peripheral areas where they contacted it on plants and at the water surface (Mozley 1978), long-term exposure interfered with metamorphosis and mating. It also appears that macroinvertebrate community composition changes and diversity decreases when oiled substrates are recolonized (Rosenberg and Snow 1975, Rosenberg and Wiens 1976, Rosenberg et al. 1977, Rosenberg et al. 1980). These studies document a few tolerant species of Ephemeroptera and Chironomidae dominating these contaminated surfaces, sometimes showing a positive response to the presence of oil.

Finally, the literature suggests that direct water quality impacts could be caused by gas sweetening plants. Aqueous discharges from these facilities will be regulated, so spills of hazardous industrial chemicals are the major concern for on-site water quality impacts. If sweetening plants are not located near water bodies, the effects to aquatic biota will probably be minimal.

No studies have assessed the potential increases, if any, in acidic depositions to nearby surface waters in Wyoming, Utah or Idaho. Sweetening plants will be the major sources of sulfur and nitrogen oxide atmospheric emissions. Most sulfur oxide (SO_2) emissions will be discharged from sulfur gas incinerators while nitrogen oxides (NO_x) will be emitted from several point sources, including gas turbine compressors and steam boilers (USDI 1980). Wyoming Department of Environmental Quality air quality permit limitations for SO_2 and NO_x at the Whitney Canyon and Carter Creek gas sweetening plants are listed in Table 2-2. For comparison, emissions from several coal-fired power plants and a copper smelter are included. From these values, it appears that the proposed combined discharges from these two sweetening plants will be approximately equal to the discharge of SO_2 from one coal-fired power plant, albeit less than a copper smelter. Atmospheric emissions of SO_2 may present a long-range acidic deposition problem (Spry et al. 1981, Western Aquatics, Inc. 1982).

Surface waters in the Overthrust Belt will probably not be acidified by sulfate depositions since they contain adequate buffering capacity. Many drainages in the Wind River, Medicine Bow, and Uinta Mountains are potentially sensitive (Omernik and Powers 1982). Only detailed drainage basin analysis and long-range sulfate and nitrate transport modeling could identify whether surface water acidification can be expected to occur.

TABLE 2-2. DISCHARGE LIMITATIONS FOR SULFUR DIOXIDE AND NITROGEN
OXIDES FROM GAS SWEETENING PLANTS IN THE OVERTHRUST BELT AND COAL-FIRED
POWER PLANTS AND A COPPER SMELTER IN THE ROCKY MOUNTAIN REGION

Emission Source	Production capacity	Discharge limitation (lb/hr)	
		SO ₂	NO _x
Amoco Whitney Canyon gas sweetening plant ^a	250 MM SCFD ^b	3,100	34
Chevron Carter Creek gas sweetening plant ^a	520 MM SCFD	1,500 ^c	260
Naughton coal-fired power plant, Kemmerer, WY ^d	710 MWe	6,300	5,430
Basin Electric coal-fired power plant, Wheatland, WY ^d	1,500 MW	3,300	11,600
Colorado-Ute coal-fired power plant, Hayden, CO ^f	465 MW	2,900	--- 9
Utah copper smelter ^f	---	19,000	--- 9

^aValues obtained from Permit Application Analysis, Wyoming Department of Environmental quality, Air Quality Division, Cheyenne, Wyoming.

^bMM SCFD = million standard cubic feet of gas per day.

^cValue reported as SO₂ equivalents; projected composition is approximately 95% COS (carbonyl sulfide), 3% H₂S (hydrogen sulfide) and 2% SO₂.

^dValues from Bernie Daley, Wyoming Department of Environmental Quality, Air Quality Division, Cheyenne, Wyoming, personal communication.

^eMW = megawatts of generating capacity.

^fValues reported in Ferraro and Nazaryk 1982.

9--- = value not reported.

Effects of increased acidity on aquatic organisms have been studied intensively and reviewed extensively (US Environmental Protection Agency 1976, Katz et al. 1979, Spry et al. 1981). Western Aquatics Inc. (1982) has assessed the relationship among acidifying depositions, surface-water acidification and fish populations in North America. These investigators conclude that low hydrogen-ion concentrations associated with acidic depositions cause acute mortalities during brief, but episodic runoff events, and reproductive failure in chronically exposed fish populations. Additionally, toxic metals such as aluminum, lead and zinc are relatively soluble in acidic waters and most likely contribute to the adverse effects of surface water acidification on fish populations (Western Aquatics Inc. 1982).

Logging and Roads. Stream habitats in the Overthrust Belt range from cold, montane trout streams to warm, lowland streams with unique communities of native fishes. Although there is abundant literature on habitat requirements for trout (e.g., Hubbs et al. 1932, Narver 1970, Bowers et al. 1979), little information is available on habitat requirements of native fishes from warm, lowland streams of this region (Baxter and Simon 1970).

Several physical characteristics of a stream determine trout presence and density (Narver 1970, Bowers et al. 1979). Optimum conditions for trout are water temperature less than 21°C (70°F), stable streambanks, streambed free of silt, extensive streamside vegetation, and instream cover. Overhead cover is an important aspect of instream trout habitat (Bouseu 1954, Butler and Hawthorne 1968, Lewis 1969, Wesche 1976, Meehan et al. 1977, Eifert and Wesche 1982), as is spawning habitat (White 1973, Meehan 1974, Reiser 1976, Reiser and Wesche 1977).

Logging can affect stream fisheries through road construction practices, increasing sedimentation rates, destroying riparian habitats, and preventing fish migration (Tebo 1965, Edgington 1969, Narver 1970, Brown and Krygier 1971, Burns 1972, Gibbons and Salo 1973, Meehan 1974, Sheridan et al. 1976, Murphy and Hall 1981). Logging can be detrimental to fish by reducing or destroying spawning habitat (Ringler 1979, Burns 1970, Moring 1982), and by altering streamflow regimes, water temperature, water quality, and food supply to the stream (Chapman 1962, Hall and Lantz 1969, Narver 1972, Newbold et al. 1980). The impacts of logging on Wyoming streams have been documented (Connell 1978, Kanaly 1970, Oberholtzer 1980). Logging practices have been developed which reduce sedimentation and impacts on riparian areas (Society of American Foresters 1959, Haupt and Kidd 1965, Packer 1967).

Construction of roads, highways, and pipeline crossings can increase sedimentation and turbidity in stream habitats and block fish upstream fish passage (Bachmann 1958, Anderson and James 1957, Burns 1970 and 1972, Megahan and Kidd 1972, Anderson and Bryant 1980). Road construction associated with logging operations has been observed to influence stream habitats in Wyoming (Mueller 1966a and 1966b). Sedimentation and habitat loss associated with road construction can reduce both sport fishery abundance (Whitney and Bailey 1959) and invertebrates important as fish food (Barton et al. 1971, Brode et al. 1973, Barton 1977, Cline et al. in press). Measures for reducing and

mitigating the impacts of road construction in biomes similar to the Overthrust Belt have been discussed in several studies (Dryden and Stein 1975, Hynson et al. 1982).

Erman et al. (1977) conducted a study in California evaluating streamside buffer strips for protecting aquatic habitats from logging and associated road construction. They found that streams protected by buffer strips wider than 30 meters did not display logging impacts and that a direct correlation existed between increases in aquatic habitat quality and increases in buffer width.

Several studies have demonstrated that timber harvesting can increase water temperatures, especially in small first- second- and third-order streams (Brown and Krygier 1967, Lantz 1971, Burns 1972, Patton 1973, Ringler and Hall 1975, Sharpe 1975). The most important cause of temperature increases appears to be removal of streamside vegetation; however, increased stream sediment loads and decreased in-stream flow both affect increases in water temperature. In turn, the water temperature increases, from whatever direct cause, can affect dissolved oxygen concentrations through reduced oxygen solubility at elevated temperatures. Hoss et al. (1979) and Katz et al. (1979) have shown these physical effects can indirectly affect fish populations through alterations in water quality parameters such as temperature and dissolved oxygen concentrations.

Several studies indicate that in addition to effects on temperature and dissolved oxygen, sedimentation caused by numerous land uses can affect fish populations in other ways (Aitken 1936, Ellis 1936, Cordone and Kelley 1961, Copeland 1969, Gebhardt 1970, Hollis et al. 1964). A paper by Cordone and Kelley (1961) incorporated a detailed description of sediment mechanisms. Sediment prevents the flow of water through gravel beds, thereby reducing spawning success of trout and other species which depend on intergravel space and water flow for egg and fry survival (Cordone and Kelley 1961, Shelton and Pollock 1966, Peters 1965, Phillips 1971, Gibbons and Salo 1973, Meehan 1974, Reiser and White 1981). In addition, sediment reduces reproductive success by preventing fry emergence from the gravel (Phillips 1971, Gibbons and Salo 1973, Meehan 1974). Other impacts of sedimentation on fish habitat include reduction in the rock substrate and other cover, as well as loss of pool depth necessary for shelter and survival of many species (Cordone and Kelly 1961, Phillips 1971). Several studies suggest that loss of rock and gravel substrate also has an influence on invertebrate production necessary as a food source for fish (Tebo 1957, 1965, Chutter 1969, Newbold et al. 1980, Lenat et al. 1981, Cline et al., in press, Gray and Ward in press). The cumulative effect of in-stream sedimentation can include an alteration of fish populations and changed abundance. This usually results in a loss of game fish, such as trout, or a reduction in the abundance of desired species (Ellis 1936, Ritchie 1972, Saunders and Smith 1965).

Livestock Grazing and Stream-Flow Manipulations. Livestock grazing is a widespread land use in the western United States. Platts (1979) stated that 83 percent of the 11 western states is in forest and range lands, and that 70

percent of the 1.2 billion acres of forest and range land nationwide is now being grazed by livestock. Livestock grazing has a serious impact to western riparian and aquatic habitats (Crumpacker 1981, Benson 1979, Warner 1979, Schmidly and Ditton 1978, Behnke and Raleigh 1978, Armour 1977, and Carothers 1977). Alteration of streamside plant communities can affect stream habitat (Greene 1950, Gunderson 1968, Gibbons and Salo 1973, Karr and Schlosser 1977, Bowers et al. 1979) for fish.

The literature indicates that grazing in riparian areas can have potential impacts on vegetation, soils, hydrology, and stream sedimentation. Should grazing activity and trampling become too severe, protective woody and herbaceous ground cover is removed, soils become compacted, infiltration of precipitation decreases, soil moisture is diminished, overland flow accelerates, the water table is lowered and erosion of topsoil begins. As vegetative root biomass is decreased and the soil binding capacity is diminished, bank sloughing is accelerated, channel stability lessens, and a change in channel morphology to a wider, shallower stream is observed (Robinson 1982, Peterson 1950, Schmidly and Ditton 1978, Hude 1976, Karr and Schlosser 1977, Meehan and Platts 1978, Thomas et al. 1978, Crumpacker 1981, Miller 1979, Moore, et al. 1979, Thomas et al. 1979, and Platts 1978 and 1979, Cooper 1979). Cattle grazing has also lead to increased nutrient pollution in small streams (Weeks 1979).

The literature indicates that other potential impacts to aquatic communities which might come from developments in the Overthrust region stem from the alteration of streamflow regimes and stage-discharge relationships. Activities such as water storage, streamflow depletion, channelization and land stabilization can all have direct physical effects on streams and associated riparian habitat through a variety of mechanisms including flooding, drought, mechanical destruction of riparian vegetation and soils (Teskey and Hinkley 1977 and 1978, Walters et al. 1980, Barclay 1980, Stern and Stern 1980).

As with other alterations, when the amount of aquatic habitat is reduced through reduced instream flow (Osborn and Allman, 1976), the composition and productivity of the aquatic community is changed (Kraft 1968, Burton 1974, Nickelson 1976, Reiser and White 1981). Osborn and Allman (1976) included a wide array of papers dealing with instream flow problems. Instream flow problems have been documented in the Overthrust Belt area (Wiley 1972, Binns et al. 1973). The impacts of channelization have been observed in Wyoming (Mueller 1966c) and specifically in the Overthrust area (Wyoming Game and Fish Department 1966, Dunning 1972).

Recreational Activities. Increases in fishing pressure may result from an increase in human population and better access to remote fisheries as a result of roads built in connection with a development. These effects could be particularly significant in regard to the Colorado River cutthroat and the Bonneville cutthroat trouts because of the peculiar vulnerability of these trout species, as has been noted by several workers (Quinlan 1980, Behnke 1976, Binns 1977).

A study by Behnke (1976) referred to this vulnerability and reported that Bonnaville cutthroat trout samples taken from stream sections near roads contained only 20 percent over six inches in length compared with a sample from more remote Raymond Creek which had 53 percent over six inches in length. Binns (1977) commented on the susceptibility of cutthroat trout to angling and the disappearance of large Colorado River cutthroat in Rock Creek and North Beaver Creek (Wyoming, Sublette Co.) where early sampling produced a few trout in the 13-15 inch range and more recent visits recovered few trout in excess of 10 inches. He cautioned against exposing Colorado River cutthroat trout to excessive fishing pressure. In reference to the Bonnaville cutthroat, Binns (1981) noted that this species is also quite easy to catch, but exhibits variation in catchability. Jespersen (1981) reported that in a small montane stream the standing crop of Colorado River cutthroat trout decreased from 67.4 kg/ha to 6.96 kg/ha, and the percentage of fish less than five inches increased from 3 percent to 31 percent between 1978 and 1979. He attributed this change to the fishery having been made known to potential fishermen. This comprehensive study on small streams in Wyoming gives insight into the probability of similar problems along the Bear River Divide. He noted that "this trout population is extremely vulnerable to the angler and is unable to withstand even moderate fishing pressure." Recreational use can also have an influence on water quality through improper sanitation facilities (King and Mace 1974).

Recreational use has the potential to modify riparian habitats and hydrologic parameters within stream ecosystems (Miller 1979, Johnson 1978, Johnson and Carothers 1980). Settergren (1977) reviewed the literature regarding impacts of river recreation on streamside soils and vegetation and found numerous similarities to grazing impacts. Nash (1978) suggests that riparian habitats have recreational carrying capacities just as they have livestock grazing carrying capacities. Schmidly and Ditton (1978) feel that recreation impacts may be less devastating to riparian zones than grazing because recreational users tend to concentrate activities, while livestock exert a more generalized disturbance.

Off-road vehicles (ORV) exert stress on the land traversed (Wilshire et al. 1979). They estimated that the typical motorcycle disturbs one hectare of land for each 77 km driven, while a four-wheel drive needs to travel only 23 km to impact the same area. The direct impacts on vegetation caused by vehicles include crushing of seedlings, root systems, and foliage by the wheels, uprooting of small plant cover; and disruption of the larger plant's root systems by soil shear stresses. As the area of a watershed stripped of its vegetation is increased, the amount of runoff occurring as overland flow is increased. This excess is diverted to unused slopes, where the added runoff initiates rill and gully erosion, thereby causing vegetation losses in areas not directly affected by ORV use (Heede 1976).

Studies of General Applicability to the Overthrust Belt

Information on some dimensions of fish communities and their habitats is available for the Bear River Divide. Stream surveys of fish communities have

been conducted in both the Green River (Bureau of Land Management 1979, Remmick 1981, Richards and Holden 1981) and Bear River (Bureau of Land Management 1979, Binns 1979, Smith 1979, Miller 1977) drainages (Baxter and Simon 1970). These surveys by the Wyoming Game and Fish Department and the Bureau of Land Management yield good insight into the fishery resources along the Bear River Divide.

Several studies indicate that streambank vegetation helps provide suitable summer temperatures, reduces erosion, serves as a silt trap to preserve gravel and instream habitat, and provides cover and sources of terrestrial insects used as food (Hansen 1971, White 1973, Behnke and Zarn 1976, Saltzman 1977, Bowers et al. 1979, Mechan et al. 1977, Davis 1977). The flow of water through a stream channel both enhances and provides instream habitat (Lewis 1969, White 1973, Cooper and Wesche 1976, Winegar 1982). Beaver ponds are important in trout streams in arid climates (Binns 1977 and 1981, Bowers et al. 1979), because of the streamflow regulation they provide.

Information on stream habitat quality is well documented for the Thomas Fork and Smith Fork drainages of the Bear River (Binns 1979), but little information is available for other tributaries. Substantial information exists on the life history and distribution of the two native cutthroat trout, Bonneville cutthroat and Colorado River cutthroat, found in the Overthrust Belt (Miller 1972, Behnke and Zarn 1976, Binns 1977 and 1981, Joseph et al. 1977). A survey of standing water habitats on a portion of the east slope of the Bear River Divide documented both fish and wildlife values (Hollings and Berry 1980). A description of water quality for southwestern Wyoming is available (CH2M Hill, Inc. 1978).

Summary of Literature Review

According to available data, the potential water quality impacts associated with oil and gas development include release of toxic drilling and reserve pit fluids, spills of crude oil, and possible acid rain generated by emissions from gas sweetening plants. Toxicity to fish of various chemicals associated with well drilling operations has been demonstrated rather extensively. Spills and discharges of crude oils and refined petroleum products often cause some limited mortality in aquatic organisms although long-term adverse effects of these products can occur at concentrations. Water quality impacts could also be caused by gas sweetening plant emissions of SO_2 if subsequent acidic atmospheric depositions occur. Surface waters within the Overthrust Belt do not appear to be vulnerable to acidification from atmospheric depositions, but waters in nearby mountain ranges are potentially sensitive.

Other water quality problems arise from surface disturbances which, although not unique to the oil and gas industry, could potentially impact fish populations during development. Road construction, logging activities, and recreational vehicle use in riparian areas can lead to increased erosion and concomitant water turbidity. Sedimentation of streams has been shown to increase water temperatures and decrease dissolved oxygen concentrations to

the detriment of fish populations. Fish reproduction is also adversely impacted by sediments derived from these sources. In general, any process eliminating or reducing the water-holding capacity and sediment trapping ability of riparian vegetation can initiate stream bank instability and increase sediment loads in surface waters. Livestock grazing in riparian areas has been shown to contribute to these problems. Aquatic habitat quality parameters for trout species are well known but little information is available on habitat requirements of native fishes from warm, lowland streams in the Overthrust Belt. Native cutthroat trout are known to be vulnerable to recreational fishing and concern exists about the influence of human population growth and increased harvest on these fish.

Summary of Data Gaps

The literature has provided documentation on several impacts expected from development such as erosion of soil from disturbed areas such as roads, pipeline rights of way, and drill pads and concomitant stream and standing waters sedimentation. Effects of increased suspended solids loads on aquatic biota are well documented in the literature. Research is needed to define preventive and mitigative measures to avoid adverse impacts of erosion in the unique soils and vegetation types of the Overthrust Belt. Specific characteristics of watersheds and drainages are likely to preclude effective implementation of a single plan or technique to ameliorate impacts to riparian vegetation, fish habitat and water quality parameters affecting terrestrial and aquatic wildlife. The effects of various soil and vegetation disturbances on erosion in drainages characteristic of the Overthrust Belt need further study.

Research on the aquatic toxicity of drilling fluids, drilling muds, and additives is still in its infancy. The limited information presented in this review suggests that the contents of mud and reserve pits could be harmful to fish and invertebrate populations. The fate and effects of reserve pit fluids and solids on active and reclaimed drilling sites are probably the biggest unknown water quality problem in the Overthrust Belt.

Finally, the potential for acidification of surface waters due to emissions from gas sweetening plants has been suggested but there is no information available on the subject. Sensitivity of different drainages to acidification varies, but baseline studies of water quality throughout the Overthrust Belt are lacking. Without baseline data, evaluations of perceived or documented acidification problems will be impossible in the future.

THREATENED AND ENDANGERED SPECIES

Introduction

Issues involving threatened and endangered species do not appear to be of major significance in the Overthrust area. Four federally-listed endangered species may inhabit the area: bald eagle, peregrine falcon, black-footed ferret, and whooping crane. These four species are listed as endangered by

the United States Department of the Interior under the provisions of the Endangered Species Act of 1973.

Literature Overview

Of the four species listed, the bald eagle has received the most attention with breeding and winter distributions documented (Oakleaf et al. 1982, Jenkins 1982) and response to human disturbances investigated (Mathisen 1968, Stalmaster and Newman 1978, Jenkins 1982). Very little information exists on peregrine falcon occurrence in the Overthrust Belt although Williams and Matteson (1973) and the Wyoming Game and Fish Department (1977) note there may be migrants and nesting is possible. Nesting habitat has been reported by Taverner (1947), Bent (1961), Jenkins (1979), and Oakleaf et al. (1982). The presence of organochlorine pesticide residues in prey species has been held responsible for reproductive failure and population declines of peregrine falcons (Peakall 1974, Wiemeyer and Porter 1970, Cade et al. 1971, Lincer et al. 1970).

Evidence for black-footed ferrets inhabiting portions of the Overthrust Belt has been presented by Martin and Schroeder (1978, 1979) and Clark (1980). Current research on an extant population of ferrets in northwestern Wyoming (Smith et al. 1982) has relevance to future investigations (Clark et al. 1982). Dependence of this predator on prairie dogs is well documented (Findholdt et al. 1982, Hillman, 1968, Portenbery 1972, Smith et al. 1982). The whooping crane may be observed in the Overthrust Belt but specific information on distribution and use is absent.

Other plant and animal species occurring in the Overthrust Belt appear on state lists of rare and endangered species (Dorn 1980, Clark and Dorn 1981, Findholdt et al. 1981).

Recovery plans exist or are being prepared for the endangered species. These plans prescribe management techniques to avoid disturbance to the species and enhance their survival. When surveys determine that endangered species might be present, the Recovery Plan should be consulted. Copies of the Plans may be obtained from USDI, Fish and Wildlife Service Director Region 6, P.O. Box 25486, Denver Federal Center, Denver CO 80225.

Status of Federally Listed Species in the Overthrust Belt

The bald eagle was distributed historically across the United States and Canada. Two subspecies of bald eagle have been described (Snow 1973, Snow 1979). The northern bald eagle breeds in Canada, Alaska, and the more northerly 48 conterminous states, including Wyoming and Idaho. The southern bald eagle nests primarily along the Atlantic and Gulf coasts, the lower Mississippi Valley, and in the southwestern United States.

The bald eagle is found primarily along lakes and rivers. A great portion of an adult eagle's life centers around nesting territory with nests constructed in tall dead or dying trees. The bald eagle has been observed breed-

ing in Lincoln County, Wyoming (Oakleaf et al. 1982). Bald eagles have been observed throughout the area, foraging in a variety of open habitats during the winter and spring (Oakleaf et al. 1982, Williams and Matteson 1973). Concentrations of wintering bald eagles are known to occur in the Woodruff Narrows area on the Bear River (30 to 50 bald eagles) and in the vicinity of Morgan Canyon (5 to 10 bald eagles). More information on these winter roosts is presented in Task 3 and Appendix D.

Big game carrion appears to contribute substantially to the diet of wintering bald eagles at the Woodruff Narrows roost (Jenkins 1982). There has been concern that road killed big game may attract bald eagles and increase the likelihood of deaths related to vehicular collisions (Oakleaf 1979). This is a possibility in the study area with substantial numbers of wintering bald eagles near US Highway 30 and Utah State Highway 16. Jenkins (1982) recommends removal of road-killed carrion from highways and roadsides to reduce the possibility of collisions.

Human disturbance effects on wintering bald eagles have been explored in Washington (Stalmaster and Newman 1978) and recently in Wyoming at the Woodruff Narrows roost and in the vicinity of the Jackson Canyon roost near Casper (Jenkins 1982). Stalmaster and Newman (1978) concluded that human approach to wintering eagles had a significant adverse effect on eagle distribution and behavior since birds were displaced to marginal habitat and were concentrated in a small area. Mathisen (1968) and Stalmaster and Newman (1978) report human activities disrupt bald eagle feeding behavior and conclude that sensitivity to human interference was greatest during feeding periods. Additionally, adult bald eagles appear to be more sensitive to disturbances than juveniles (Stalmaster and Newman 1978). Aircraft and vehicles elicited an escape response most often in the Jackson Canyon area while no responses to aircraft were noted for eagles in the Woodruff Narrows area. However, vehicles and humans did cause eagles to leave perches and exhibit moderate to severe avoidance at the Woodruff Narrows roost (Jenkins 1982).

The American peregrine falcon has a historic distribution across North America from Mexico to Canada (Snow 1972a). Presently, this falcon breeds in the western part of the United States. A basic peregrine falcon habitat requirement is cliffs which are used as nesting sites. Favored cliffs are extremely high, frequently overlook water, and permit an extensive view of the surrounding countryside (Taverner 1947, Bent 1961). Peregrine falcons have been quite tolerant of human intrusion, to the point of nesting on skyscrapers in cities. The primary limiting factors to peregrine falcon survival have been organochlorine pesticides and habitat loss. Eggshell thinning due to sublethal, chronic intake of organochlorine pesticide residues has resulted in limited reproductive success (Peakhall 1974, Wiemeyer and Porter 1970, Cade et al. 1971). Even peregrine nesting in Alaska are not exempt since they feed on migratory waterfowl exposed to pesticides on wintering areas (Lincer et al. 1970).

American peregrine falcons are frequently encountered as migrants in the Overthrust area (Williams and Matteson 1973). They seldom nest in the area

due to the scarcity of water. Almost all known peregrine falcon nests are within 0.8 km of water (Jenkins 1979, Oakleaf et al. 1982). Peregrine falcons have been reported nesting in the vicinity of the Green River in Sweetwater County, Wyoming (Wyoming Game and Fish Department 1977).

Black-footed ferrets historically occurred across the plains states (Snow 1972b). The ferret is thought to be associated with prairie dog towns where it preys upon prairie dogs and other rodents and uses their burrows for shelter (Hammer, personal communication). The reasons for black-footed ferret decline include loss of habitat and extensive programs to control prairie dogs on range lands (Findholt et al. 1981).

Recent searches for ferrets have turned up evidence of their past occurrence in the Overthrust area (Clark 1980, Martin and Schroeder 1978, 1979, 1981; Hammer and Schroeder 1980, McDonald and Schroeder 1980).

In October, 1981, a small population of black-footed ferrets was found in northwestern Wyoming (Smith et al. 1982). Currently, Wyoming is the only state known to contain a live population of black-footed ferrets. Over a 32-year interval (1947-1979) there have been seven probable sightings of black-footed ferrets in Sublette County, one positive and one probable sighting in Lincoln County, and three black-footed ferret skulls and two possible scats found in Uinta County (Clark and Campbell 1981, Martin and Schroeder 1979, 1981). Other literature on ferret surveys in the Overthrust Belt includes papers by Clark (1980), Hammer and Schroeder (1980), and McDonald and Schroeder (1980). Additional information on ferret surveys in and near the study area are reported in Task 3 and in Appendix D.

There are two basic techniques developed by Henderson et al. (1969) being used to conduct black-footed ferret surveys, night-time and day-time surveys. Night-time surveys consist of scanning a prairie dog town between sunset and sunrise with spotlights. Ferrets are located by searching the prairie dog town for green eyeshine, characteristic of black-footed ferrets. Although much of the basic ecology of the black-footed ferret in white-tailed prairie dog towns is not clearly understood, it has been shown that a great proportion of a ferret's daily activity pattern occurs during the night-time hours (Hillman 1968, Schroeder, personal communication), therefore enhancing the effectiveness of this technique in locating black-footed ferrets.

Day-time surveys consist of searching a prairie dog town in an attempt to locate physical evidence indicating the presence of a black-footed ferret. Each town is systematically walked in a zig-zag manner, during which time all burrow openings five cm in diameter or larger are examined for signs of ferrets, such as ferret-created trenches, scat, plugged burrows, prairie dog skulls with puncture marks near the base of the cranium, and ferret skulls (Fortenbery 1972).

Recently, Clark et al. (1982) provided detailed information on black-footed ferret sign including snow diggings, tracks, dirt diggings, scat, burrow hole-plugging by prairie dogs and prairie dog skull punctures. Much of

this information has been evaluated from recent studies of the Meeteetse, Wyoming, black-footed ferret population. Day-time surveys during winter months (December 1 to April 15) are now thought to be advantageous since prairie dog activity is minimal and fresh ferret sign is less apt to be obliterated (Clark et al. 1982).

The whooping crane is another endangered species which has been observed in the area (Oakleaf, personal communication). This species may be observed migrating through the area, but does not breed or winter in the vicinity.

Studies by the Wyoming Game & Fish Department (1977) indicate that loss of whooping crane breeding areas in shallow marshes and prairie sloughs is, in part, responsible for the decline of this species.

While not on the Federal list of endangered species, other plant and animal species occurring in the Overthrust Belt appear on state lists of rare and endangered species (Dorn 1980, Clark and Dorn 1981, Findholt et al. 1981). The lists include the following plants and animals in the study area.

Plants

- Tufted twinpod
- Dorn's twinpod
- Matted pussytoes
- Thickstem peavine
- Juniper tomatium
- Bun Milkvetch
- Sac saltbrush
- Annual wildbuckwheat
- Creeping bladderpod
- Paysons beardtongue
- Watson beardtongue
- Dissected prince's plume
- Stemless wildbuckwheat
- Parson milkvetch
- Fire chalice

Fish

- Colorado River cutthroat trout
- Bonneville cutthroat trout
- Leatherside chub
- Bluehead sucker
- Flannelmouth sucker
- Roundtail

Amphibians and reptiles

- Northern tree lizard
- Midget faded rattlesnake

Northern plateau lizard
Salt Lake short-horned lizard

Mammals

Mountain lion
Bobcat

Additional information on local documented occurrence of some these rare species is presented in Task 3 and Appendix D.

Summary of Literature Review

The effects of human disturbances have been investigated for bald eagles but are not reported for other Federally-listed endangered species potentially inhabiting the Overthrust Belt. Distribution information is also available for bald eagles, but quite scanty for peregrine falcons, whooping cranes, and black-footed ferrets in the study area. Peregrine occurrence and nesting habitat is known from the literature and susceptibility to pesticide residues is well documented. Black-footed ferrets are likely to inhabit portions of the Overthrust Belt and techniques for ferret surveys and habitat evaluation are being refined through research on Wyoming's only known population of Black-footed ferrets. Whooping cranes are expected to occur in the area only as occasional migrants. Additional species of plants and animals are listed by states as rare or endangered.

Summary of Data Gaps

No special effort is recommended to evaluate endangered species based on the literature. Developers should be aware of what species could inhabit the area. Recovery plans should be consulted when an endangered species is thought to be in the area. The permit processes for each activity adequately dictates what action should be taken to determine the presence of endangered species and avoid adverse impacts. Suggestions to continue surveys are made in the public knowledge section.

STRESS

Introduction

Stress is a physiological state of an animal which results from noxious environmental stimuli known as "stressors". (Most of the available data used to evaluate the effects of stress on wildlife comes from laboratory studies.) In evaluating the effects of development on wildlife, it is important to realize that a stressor is not simply a direct threat of physical damage to an animal, but may include a complexity of psychological neurogenic stressors such as unfamiliar objects, sounds, or noises in its environment. It is difficult to fully evaluate the impact of stress because there has been only limited research on the subject. While data are not available, many investigators felt that stress has an adverse impact on wildlife.

In the available literature stressors associated with development have been categorized into two groups:

1. Somatic stressors (bone fracture, soft tissue damage, etc.) which may result from:
 - a. road injuries of game and nongame species,
 - b. hunting injury of game species,
 - c. flight injury of avian species colliding with telephone lines, communication towers, and other structures,
 - d. injury resulting from contact with fencing, shallow excavations, etc., and
 - e. tissue damage or physiological impairments caused by contact with toxic substances in terrestrial or aquatic habitats.
2. Psychological neurogenic stressors (alarm, fear, apprehension, anxiety) which may result from:
 - a. noise related to recreation and industrial activities,
 - b. harassment by hunters, sightseers, dogs, etc.,
 - c. unfamiliar objects in the environment such as trailers, rigging towers, generators, heavy equipment, etc., and
 - d. alteration of the topography, reduction of food or water availability.

Various somatic stressors to wildlife were reviewed in previous sections on big game, furbearers, raptors, game birds, nongame wildlife, amphibians and reptiles, and fish and will not be discussed here. This section emphasizes the known literature relating psychological stress and physiological functions in wildlife and laboratory animals.

Literature Overview

Available data indicates that psychological stress of wildlife leads to various physiological responses which in turn affect the animals' potential for survival and reproduction. Stress associated with wildlife capture and handling has been examined by Chalmers and Barrett (1977), Franzmann and Thorne (1970), and Seal and Hoskinson (1978). Stressed animals exhibit neural and hormonal response related to avoidance or attack behavior. Chronic stress in laboratory animals produces pathological conditions leading to reduced resistance to parasites (Shwartzman 1950) and disease (Albernathy 1951, Kass et al. 1951). Jenkins and Kruger (1975) determined that chronic stress produces elevated glucocorticoid levels which inhibit antibody production

(Kass et al. 1953), reduce leukocyte and macrophages (Stuart 1952), and inhibit inflammation during healing (Dougherty 1953, Dougherty and Schneebeil 1950).

Several investigators have reported stress in wildlife. Enlarged adrenal glands in voles (Leleng and Tamrin 1977 and Sitka deer (Christian et al. 1960), and elevated glucocorticoid levels in moose (Franzmann et al. 1975), mule deer (Trindle et al. 1978) snowshoe hares (Dietrich and Feist 1980, Feist 1980), and feral horses (Kirkpatrick et al. 1970) have been related to overpopulation, noise, and vehicular harassment. In controlled laboratory and enclosure studies, human harassment, noise or unfamiliar objects have caused decreased reproductive function through various hormonal abnormalities associated with high glucocorticoid levels (Pollard et al. 1980, Seal et al. 1983, Howarth and Hawk 1968, Hayino et al. 1969, Rowell 1970, Arvay 1967, Reid and Mills 1961, Gibson 1970).

While stress and its physiological effects are becoming better known, problems with measuring appropriate parameters in free-ranging animals remain. Kanwisher et al. (1978), Ward et al. (1976), and MacArthur et al. (1979, 1981) have employed heart-rate telemetry as a means of evaluating psychological response of wildlife to disturbance stimuli but other physiological conditions cannot be determined. Nevertheless, heart-rate telemetry provides insights to wildlife perception of disturbances when overt behavioral responses are absent (Thompson et al. 1968, Moen et al. 1978).

Studies of General Applicability to Resource Development

Data on specific effects of stress on animal populations are few, but what data is available suggests that psychological stressors associated with unfamiliar surroundings, overcrowding, and disruption of territory cause stress. Generally, the data indicate that the stress response represents an aggregate of body reactions whose purpose is the survival and protection of the organism during adverse conditions. Initially, the animal perceives the stressor, integrates its importance, and responds through neural and hormonal adjustments culminating in an avoidance or attack behavior. A 1980 study by Pollard and his coworkers indicates that if the stressor is chronic and cannot be removed through a flight or fight response, the stress response may become pathological and result in increased mortality or impaired reproductive function.

Several investigators, including Chalmers and Barrett (1977), Franzmann and Thorne (1970), and Seal and Hoskinson (1978), have attempted to evaluate the stress of capturing big game through measurements of many parameters such as serum glutamic-oxaloacetic transaminase (SGOT), creatine phosphokinase (CPK), cortisol, progesterone, and various hematological parameters. Perhaps the most rigorous study of physiological changes on animals due to stress related to high density was conducted by Seal et al. (1983) on a captive herd of white-tailed deer. However, what these studies fail to provide is a method of monitoring and evaluating physiological changes in free-ranging animals. This is unfortunate since many questions about the impact of stress on the

health and viability of populations exposed to new perturbations must, for now, go unanswered.

The influence of chronic stress on reducing the resistance of animals to infection and disease has been documented in laboratory situations. A 1975 study by Jenkins and Kruger indicates that stress causes a persistent elevation of plasma glucocorticoids. Injections of these hormones into animals to duplicate stress concentrations in a laboratory situation cause a reduced resistance to parasites (Shwartzman 1950) and disease (Abernathy 1951, Kass et al. 1951). This is caused by inhibition of antibody production (Kass et al. 1953), reduction of leukocytes and macrophages (Stuart 1951), and inhibition of inflammation during the healing process (Dougherty 1953, Dougherty and Schneebeil 1950).

These observations have been documented in captive and free-ranging wildlife populations in response to a variety of environmental stressors. For example, stressors such as overpopulation, vehicular harassment, and loud noises have been demonstrated to cause enlarged adrenal glands (Leleng and Tamarin 1977) and elevated plasma glucocorticoid levels in Alaskan moose (Franzman et al. 1975), snowshoe hare (Dietrich and Feist 1980, Feist 1980), mule deer (Trindle et al. 1978), sheep (Reid and Mills, 1961), monkeys (Rowell 1970), various birds (Cheville 1978), and feral horses (Kirkpatrick et al. 1970). Two studies on free-ranging wildlife populations have linked mortality to stress related causes. Sitka deer developed glomerulonephritis which is attributed as the ultimate cause of high mortality in herds exposed to chronic stress conditions and consequently elevated glucocorticoids (Christian et al. 1960). A classic, often cited but unproven example of stress-induced mortality is a herd die-off of bighorn sheep in Waterton Canyon, Colorado, during a period of road and dam construction (Spraker and Hibler 1977). The investigators believed that the continuous stressors of human harassment and vehicular traffic resulted in stress-induced elevated glucocorticoid levels which lowered the herd's resistance to parasites. With this lower resistance, and the inhalation of heavy airborne dust pollutants caused from vehicular traffic, large numbers of the animals died of verminous pneumonia.

In laboratory and field enclosure studies, it has been suggested that stress due to psychological stressors, such as human harassment, noise, or unfamiliar objects in the environment, cause hormonal abnormalities of the reproductive system. Stress and increased glucocorticoids cause elevated testosterone levels in rats (Pollard et al. 1980), increased progesterone production by white-tailed deer (Seal et al. 1983), increased abortion of implanted embryos in sheep (Howarth and Hawk 1968), reduced ovulation (Hayino et al. 1969), increased follicular phase length and longer menstrual cycles in baboons (Rowell 1970), increased luteal phase and uterine weight in rabbits (Arvay 1967), pregnancy toxemia in sheep (Reid and Mills 1961), and spontaneous abortion in coyotes (Gibson 1970). These reproduction impairments are believed to be a consequence of stress induced abnormalities of steroid hormone levels although this remains to be proven.

Lund and Folk (1976) studied the physical condition of the animal in relation to reproductive fitness. Their study suggested but did not prove that chronic environmental stressors may interfere with feeding behavior or assimilation efficiency of animals, thereby reducing the amount of fat storage. A threshold of fat deposits is necessary for an animal, first, to successfully breed and, second, to maintain a developing fetus throughout gestation. Below this "fat threshold" hormonal regulation of ovulation is disrupted, thereby impairing successful fertilization. Without sufficient fat stores, embryos and even the fetus will be either absorbed or aborted.

Closely associated with the reproductive system is the seasonal regulation of antler growth and shedding by Cervids. Growth and shedding of antlers is under the control of testosterone and glucocorticoid hormones (Bubenik 1966). With increased human activity, Sitka deer had elevated plasma levels of both testosterone and cortisone which delayed the shedding of antlers for periods up to one year (Topinske 1975).

Through the use of motion-activated and time lapse cameras, radio tracking, ground and aerial reconnaissance, pellet group transects, and check stations, researchers have documented that elk tend to move away from sites of logging and road-building (Roberts 1974, Black et al. 1976, Gruell and Roby 1975, Ward 1975). On the elk winter range of Wyoming, seismic activity up to five km away caused elk to move from the testing area (Hoskins 1981). However, Bennington et al. (1982), using tracking methods similar to the above studies, indicated that elk returned to drill pad sites within two to four weeks after construction activities were abandoned. Pronghorn antelope appear to habituate to vehicular activity by remaining near highways and roads (Reeve, unpublished data) and show little outward sign of stress in response to aircraft overflight (Luz and Smith 1976).

The previous methods of measuring stress (i.e. movement from an area or visual signs of distress) are limited in that they are difficult to quantify. Heart rate telemetry allows monitoring of both the location, as well as a vital physiological parameter of free-ranging animals at long distances. Recent studies on free-ranging birds (Kanwisher et al. 1978) and ungulates (Ward et al. 1976, MacArthur et al. 1979) have demonstrated that heart rate is a sensitive indicator of alarm during the stress response. It is important to note that a heart rate response to environmental stimuli often is monitored in the absence of overt behavioral changes (Thompson et al. 1968, Moen et al. 1978). For example, Ward and Cupal's (1979) study of heart-rate telemetered elk provided heart-rate and behavioral responses of elk to disturbance stimuli. When gunshots occurred within 450 meters of animals an increased heart-rate was detected 88 percent of the trials even though animals moved only 50 percent of the time. Likewise, trail bikes within 50 meters of elk produced positive heart reactions on all occasions but animals moved away from the disturbance on only 25 percent of the trails. Therefore, heart rate telemetry adds a new dimension to monitoring stress other than simple field observations. However, there are distinct limitations on the physiological interpretation of heart rate signals. Lund and Folk (1976) cautioned that heart rate is a good indicator of energy expenditures only at low levels of exercise.

Therefore, excitement from stress, which is known to be energetically expensive, may not be predicted from heart rate. However, just as important, heart rate does provide a measure of the time over which a disturbance may influence the metabolic rate of an animal and, therefore, indicates the extent and duration the stressor was perceived (MacArthur et al. 1979).

Research is currently underway at the University of Wyoming to determine if heart-rate of bighorn sheep is correlated with changes in blood hormone levels. Results from this study should clarify the issues of heart-rate as a measure of stress in free-ranging animals.

Summary of Literature Review

Wildlife and laboratory animals can be stressed by various environmental conditions from which they may or may not be able to escape. Stress associated with animal capture and handling can be severe although the stress producing situation is gone once the animals are released. Long-term disturbances from which animals cannot escape may produce chronic pathological conditions. Overcrowding, frequent harassment, noise, unfamiliar objects and decreased nutrients may cause elevated plasma glucocorticoid levels resulting in reduced resistance to disease and parasites and inhibition of the healing process although research in this area is by no means conclusive. Furthermore, reproductive functions may be impaired. Thus, individuals survival and reproductive potential decrease under chronic stress conditions.

Behavioral response of animals in field studies has been employed to detect the influence of disturbances. Recently, heart-rate radio telemetry has been used to monitor psychological and physiological responses to obnoxious stimuli with free-ranging animals. While heart rates do not accurately reflect metabolic expense of a disturbance to an animal, they can indicate the extent and duration the stressor was perceived.

Summary of Data Gaps

Most studies of stressful conditions and concomitant physiological response have been conducted under laboratory or field-enclosure conditions with captive animals. Currently, only heart-rate telemetry is available to researchers investigating psychological stress and physiological response in free-ranging animals. Efforts to examine blood parameters of captured wildlife are plagued by the short-term stress response to the capture event itself. Thus, evaluation of chronic stress conditions in wildlife populations is awaiting identification of parameters indicative of long-term stress and which can be separated from the effects of capture and handling. Heart-rate telemetry is a promising tool for use in field studies, but no information is available correlating heart rate with changes in blood hormone levels that may lead to pathological conditions relevant to individual survival and reproductive potential. Furthermore, the effects of stress in open wildlife populations are unknown. If animals can escape or become accustomed to a disturbance, in theory, the stress level should be reduced and the individual would not suffer from chronic stress responses. Although wildlife have been

observed in proximity to human disturbances, it is unknown whether these individuals are more tolerant of the activity than individuals located further away. These would appear to be very basic topics to be addressed in impact studies on a national level.

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- Information on ecological characteristics, such as limiting factors, can be particularly valuable for evaluating the effectiveness of mitigation measures. Data regarding impacts resulting from various other land uses can also suggest direction for mitigation possible efforts.
- The Task 2 investigation resulted in identification of information gaps concerning wildlife resources in the study area. These gaps are discussed in the "Findings" section of this chapter. They take several forms: single lack of information, problems in applying the information to wildlife management in oil and gas development areas, and lack of evaluation for mitigation efforts.
- Single information gaps for species or species groups were most commonly encountered. In most cases these gaps involved nongame species, which tend to be of lesser interest to both wildlife management agencies and the general public. However, the ecological relationships of different species and species groups and different land uses are usually poorly understood.

LOCAL KNOWLEDGE

INTRODUCTION

Task 3 was intended to provide a local context for the other tasks in the Cooperative Wildlife Program by applying the information developed in other tasks to the situations in the study area. Local resource managers require up-to-date accurate information to fulfill their management responsibilities. This goal has been furthered in Task 3 by identifying and evaluating information on wildlife resources in the study area.

The suitability of information for planning was a key evaluation factor. Wildlife and land managers, as well as company ecologists, generally agree that planning can allow avoidance of some impacts, assist in adequate assessment of other impacts, and help implement effective mitigation measures. To be of value for planning, a document must accurately describe wildlife resources present in the study area. Identification of sensitive resources or areas is particularly important. Finally, geographic specificity, or the potential applicability to specific geographic locations, is vital for planning purposes.

Information was evaluated for use as baseline data against which present conditions and future impacts can be compared. If impacts are to be properly evaluated, the wildlife parameters changed by the impact should have been investigated prior to development or collected on both impact areas and on unaffected control areas. Studies that provide predevelopment data on wildlife distribution, seasonal abundance, behavior, productivity, and habitat interactions are of prime importance if repeatable methods and sound analytical procedures were used. Studies discussing impacts currently occurring in the study area can be used to determine how oil and gas development is related to other land uses.

Information on ecological characteristics, such as limiting factors, can be particularly valuable for evaluating the effectiveness of mitigation measures. Data regarding impacts resulting from various other land uses can also suggest direction for mitigation possible efforts.

The Task 3 investigation resulted in identification of information gaps concerning wildlife resources in the study area. These gaps are discussed in the "Findings" section of this chapter. They take several forms: simple lack of information, problems in applying the information to wildlife management in oil and gas development areas, and lack of evaluation for mitigation efforts.

Simple information gaps for species or species groups were not commonly encountered. In most cases these gaps involved nongame species, which tend to be of lesser interest to both wildlife management agencies and the general public. However, the ecological relationships of different species and species groups and different land uses are usually poorly understood.

Application problems were common. In many cases existing data are not suitable for baseline purposes or impact assessments. This problem is due to a lack of pre-development data or data from undeveloped control areas, or the resolution of the data collected. Some data has been collected on small portions of the study area or outside of the study area, requiring extrapolation. Applying information of this type involves risks due to variation and dissimilarities between geographic areas.

PRODUCTS

The major product of Task 3 is the annotated bibliography included in Appendix E. This chapter summarizes the findings of the search for local knowledge and the information contained in the annotated bibliography. Maps in the annotated bibliography indicate areas covered by mapped data that was evaluated unless the area covered is simple to describe in text.

The annotated bibliography is intended to provide the basic information needed to evaluate the existing state of understanding of wildlife resources in the study area. The entry for each citation includes the consultants' subjective evaluation of its value. The additional information in the evaluations provide more detail and could be used either to arrive at an independent conclusion or to evaluate the documents for other purposes.

The citations in the annotated bibliography include three types of information: location, descriptions, and evaluations. Location information includes the citation, the location where a copy can be obtained, and in the case of raw data, the name of a contact person. A statement on design, describing what information was collected and how it was collected, is given. This information also includes descriptions of the timing or duration of studies and the data reduction or analysis methods. The geographic area covered and resolution are described for maps. In addition to the subjective evaluations, the entries include evaluations of conclusions, value for baseline data, and potential for further study.

FINDINGS-EXISTING KNOWLEDGE

The following section summarizes the types of information available in each of the three states. Primary information sources are discussed below, but information is often also available from other sources. The reader should refer to the annotated bibliography for detailed descriptions of documents. Tables 3-1, 3-2, and 3-3 summarize the general types of information available for wildlife priority class 1.

Utah

Big Game. There is a large amount of information on big game available from three primary sources: the Utah Division of Wildlife Resources (UDWR), Utah State University (USU) at Logan, and the US Forest Service (USFS). Harvest reports and population estimates are available from UDWR as annual big game reports on deer, elk, and moose (Utah Division of Wildlife Resources

TABLE 3-1. WILDLIFE PRIORITY CLASS ONE RESULTS, UTAH

	Big Game	Game Birds	Endangered Species
Federal Agencies	Habitat maps Pellet group transects Forage availability	Habitat and distribution maps Herbicide/sage grouse studies	Wintering bald eagle telemetry data Black-footed ferret sightings
State Agencies	Annual harvest data Annual hunting pressure data Annual population data Known illegal kills Range inventories Maps of seasonal ranges and migration routes	Annual harvest data Annual hunting pressure data Habitat and distribution maps	Current and potential distribution maps
Regional and Local Agencies	Maps of seasonal ranges and migration routes	Habitat and distribution maps	Sighting maps
Universities	Historic herd management plans Population dynamics studies Carrying capacities studies Dietary and nutritional studies	Waterfowl studies Mitigation techniques for ring-necked pheasant and sage grouse	Endemic fish studies

TABLE 3-2. WILDLIFE PRIORITY CLASS ONE RESULTS, WYOMING

	Big Game	Game Birds	Endangered Species
Federal Agencies	Distribution Impacts Habitat use Range trends	Lek locations Winter areas Waterfowl use	Bald eagle roosts Black-footed ferret surveys Peregrine falcon surveys Cutthroat trout management
State Agencies	Reproduction Population Seasonal ranges Habitat use Movement patterns Hunter harvest Illegal harvest	Lek counts and locations Grouse brood counts Grouse harvest Waterfowl nesting Goose habitat use Waterfowl harvest Depredations	Cutthroat trout surveys Bald eagle roosts Black-footed ferret surveys
Industry	Distribution Seasonal population Movements Habitat association	Lek counts and locations Brood counts Winter areas Movements	Black-footed ferret surveys
Universities	Range use Movements Range trend	Goose nesting structures Goose nesting success	
Private	Estimated impacts		Black-footed ferret surveys Bald eagle sightings Rare plants

TABLE 3-3. WILDLIFE PRIORITY CLASS ONE RESULTS, IDAHO

	Big Game	Game Birds	Endangered Species
Federal Agencies	Habitat maps Winter range evaluations Habitat manipulation programs Management plans Aspen studies	Waterfowl censuses Waterfowl nesting counts Redhead habitat acquisition plan Habitat manipulation programs Distribution maps	Bonneville trout plans and data Nesting and wintering bald eagle data Endangered species management plans
State Agencies	Annual harvest data Annual population data Habitat use and movement pattern data Studies of mining impacts Computerized evaluations Habitat maps Management plans Aspen studies	Annual upland bird harvest data Forest grouse habitat data Regional management plans Waterfowl censuses	Bald eagle surveys Peregrine falcon surveys
Universities	Poaching study	Forest grouse habitat study Sharp-tailed grouse habitat/herbicide study	Endemic fish studies

1979, 1980a, 1981, etc.). Similar information is contained in separate annual black bear (Burruss 1980a, 1980b, Fitzgerald 1982, etc.) and cougar (Fair 1977, Burruss 1980c) harvest reports. The data in these reports are broken down by herd units or counties, and include the numbers, sex, age, and similar information on the animals taken for the year of the report. A comparison with historical hunting data is often provided. Hunting pressure data in terms of numbers of permits sold and number of hunter-days as well as hunter success data in terms of hunting days per animal taken are presented by herd unit. The black bear reports also present data on the number of bears treed and damage reports. The harvest reports are supplemented by additional annual big game investigations and recommendations reports (Utah Division of Wildlife Resources 1977, 1980b). These reports repeat much of the information in the harvest reports, but contain additional information on both the animals and the hunters. Deer data in these reports include browse and pellet group transect results, pre- and post-hunt herd composition and fawn production per 100 does, and a narrative description of herd and range condition. Elk data include pellet group results, known illegal kills, herd composition, and descriptions of land ownership, range condition, and herd condition. Information is also presented on moose in the study area, including land ownership of the range and herd composition.

UDWR has prepared big game range inventories of the deer herd units in the study area (King and Muir 1971, King and Olson 1972, Guinta 1979, etc.). Vegetation types present in the herd units are mapped and described by line intercept and plot data which indicate the percent cover, pounds of forage per acre, and pounds of forage unit-wide for each plant species or species group. Winter range for normal and severe winters is also mapped on the basis of aerial and ground surveys.

Two mapping systems are in use for big game management: one prepared by UDWR (Utah Division of Wildlife Resources in preparation a,b,c) and another done by USFS (USDA Forest Service n.d.). The UDWR maps contain most of the same information as the range inventory maps for deer, but also present year-round and seasonal range and migration route information for elk and moose. The UDWR big game maps are geographically complete, covering the entire study area with minimum polygon sizes of 30 to 500 acres. The USFS maps, which only cover National Forest lands, have similar information at a higher level of resolution.

Theses and dissertations of graduate students at USU are also a major source of big game information. Most theses have been done immediately west of the study area (Bartels 1941, McCormack 1951, Follis 1972, Fierro 1977, Zwank 1979), yielding information which may be applicable to the study area and which may be useful for historic context. Several theses were done within the study area. Collins (1977) studied the diet of elk in Summit County. Babcock (1977) and Wilson (1971) studied the diet of moose on the north slope of the Uinta Mountains, which Wilson used to calculate the carrying capacity and ideal herd composition on the range. Babcock used both nutritional and census data to calculate carrying capacity, and obtained a higher carrying capacity than Wilson. Studies of population dynamics of deer herds in the

study area were done by Beall (1976) and Hickman (1971). Hickman also presents data on harvests and condition of deer. Some theses and dissertations have been published by UDWR.

Game Birds. Three primary sources, UDWR, US Bureau of Land Management (BLM), and USU, have extensive information on game birds. UDWR annually publishes harvest reports for upland game birds (Leatham and Bunnell 1981, Bunnell and Leatham 1980, Leatham and Roberson 1979, etc.). These reports contain data on sage grouse, forest (blue and ruffed) grouse, mourning dove, ring-necked pheasant, California quail, chukar, Hungarian partridge, and wild turkey (latter not in the study area). Harvest totals, hunting pressure in terms of hunter numbers and hunter days, and hunter success in terms of bag per day data are extrapolated from a sample of about 10 percent of the licensed hunters and presented on a state-wide and county-wide basis with top counties identified. These data (state-wide only) are compared with historical periods of varying lengths in the reports, showing trends in the upland game bird hunts.

UDWR has developed a mapping system for upland game birds (Utah Division of Wildlife Resources in preparation d,e) which indicates the distribution of ruffed and blue grouse, California quail, chukar, Hungarian partridge, white-tailed ptarmigan, and ring-necked pheasant. Sage grouse leks, winter range, and breeding range are also mapped. These maps have been expanded and used for management by local agencies (Bear Lake Regional Commission n.d. c) and the BLM. BLM maps (USDI Bureau of Land Management n.d.) contain field verified, more current, and a few more sage grouse lek locations than the original UDWR maps.

Theses from USU are the major source of waterfowl data and a secondary source of upland game bird information. The main value of the upland game bird work is to evaluate mitigation techniques for ring-necked pheasant and to predict the response of sage grouse to grass seeding, so these were referred to Task 5. Most of the waterfowl work was done in the Cache or Great Salt Lake valleys, so findings would have to be verified in the study area. However, Reeves (1954) studied waterfowl production at Bear Lake in Idaho, and Peterson (1969) describes the waterfowl production of lakes and identifies the most productive types of waters in the Uinta Mountains. Information on current and historic Canada geese production, location, survival, and harvest locations is in Tautin (1976).

Endangered Species. The main sources of information on endangered species are UDWR and the USDI Fish and Wildlife Service (FWS), but relatively little information is available. Endangered species information can be found on several UDWR maps. Bald eagle winter concentration areas and roosts are shown on the threatened, endangered, and sensitive species maps; bald eagle winter concentration areas are also shown on the raptor maps, and hawk sites for peregrine falcons and bald eagles are shown on the introductions and expansions maps (Utah Division of Wildlife Resources in preparation f,g,l). Several years of data from the Annual Midwinter Bald Eagle Survey, sponsored by the National Wildlife Federation, are available from both UDWR and FWS.

Several bald eagles have been trapped and tagged or fitted with radio collars, and some have been relocated in the study area, but results of the studies are not yet available (Jenkins 1981, Sabine n.d.). A number of possible sightings of black-footed ferrets have been made in Rich County, but these have not been documented. Multi-state compilations of the results of searches and unverified sightings of black-footed ferrets are available from FWS (Jobman and Anderson 1981).

Furbearers. UDWR is the primary source of furbearer data. Harvest reports for furbearers in the study area have been published annually for many years (John 1971, Jensen 1974, Provan 1978 etc.). The data include the numbers harvested, damage complaints, and qualitative population estimates. This information is broken down by county, beaver management area, or occasionally by drainage. The population information varies considerably from year to year, but at its most detailed indicates if a stream is under-, over-, or properly stocked with beaver; whether the population is increasing, decreasing, or stable; and evaluates past management strategies and recommends a general management strategy. Data on marten, otter, and muskrats appear either sporadically or regularly for a few years for other parts of the state. UDWR is preparing a mapping system which indicates beaver, otter and marten habitat in the study area (Utah Division of Wildlife Resources in preparation h). The beaver data on these maps is detailed: information on the year surveyed, gross suitability based on stream gradient, valley width and parent material, and acres of aspen and acres of willow appears on the maps. Otter and marten habitat is indicated wherever there is suitable coniferous forest.

Game Fish. Game fish information is primarily available through UDWR, but USFS, BLM, the U.S. Bureau of Reclamation (USBR), and USU are secondary sources which supplement UDWR data. Game fish habitat data in the forms of maps and computer printouts (Utah Division of Wildlife Resources in preparation g; Utah Division of Wildlife Resources n.d.) are extensive, covering all waters with fisheries in the study area. The maps indicate cold and warm water fisheries, rankings (crucial-critical, high priority, substantial value, and limited value), stream classes from the computer printouts, need for year-round protection, dewatered streams, conflicting developments, and the presence of 67 species of fish, both native and stocked. The printouts indicate stream class (based on access, aesthetics, and other human factors), productivity on a scale of 1-5, a list of fishes present, and a fishery value class on a scale of 1-4 (based on presence of threatened, endangered, or high interest species, and restoration, reclamation, and mitigation potential). The USFS has game fish habitat data for some streams which expands on UDWR data. More recent USFS stream surveys have collected information on valley bottom width, geologic landform, width of the riparian zone, aquatic vegetation, presence of beaver, and aquatic invertebrates used as an indicator of habitat quality (USDA Forest Service n.d.) Older surveys have collected similar information in a less quantitative manner (Hrostowski and Williams 1970). The BLM has stream habitat quality data supplementing UDWR data for most streams on BLM land (USDI Bureau of Land Management n.d., Ryan 1976). The BLM data is recorded on standard BLM forms and is often supplemented by color photographs. USBR has population and habitat data for parts of the

Provo River system within the study area (White 1972, Radant 1976), and has compiled the results of stream surveys by USFS, WGFD, and UDWR in the Black's Fork drainage (USDI Bureau of Reclamation 1975). The Logan River has been extensively studied by students at USU; Summers (1979) studied hooking stress in various game fishes in part of Summit County as research for his master's thesis.

Raptors. UDWR and BLM have a moderate amount of data available on raptors, most of which is in the form of maps. BLM maps for the Randolph Unit Resource Analysis (USDI Bureau of Reclamation n.d.) include precise locations and dates of occupancy for nests, and are often supplemented by text and color photos of the nest sites. The maps include only part of the study area. UDWR maps cover the entire study area, indicating winter bald eagle concentrations and nests of golden eagles, ferruginous hawks, red-tailed hawks, prairie falcons, and great horned owls. These locations are accurate to within 1 mile (Utah Division of Wildlife Resources in preparation i). Bear Lake Regional Commission maps (Bear Lake Regional Commission, n.d. b) show the locations of osprey nest areas, bald eagle roost potential peregrine falcon nest areas, and turkey vulture aeries at resolutions ranging from 70 to 250 acres.

Riparian/Aquatic Habitats. There is a moderate amount of data on riparian and aquatic habitats that can be obtained from UDWR, BLM, and the U.S. Army Corps of Engineers (ACE). Aquatic habitat data from UDWR consists of fisheries habitat information discussed above (Utah Division of Wildlife Resources n.d.) and information on the UDWR wildlife maps. The UDWR Fisheries and Aquatic Habitat maps (Utah Division of Wildlife Resources in preparation g) indicate habitat information as discussed earlier for game fish, and also show the locations of other aquatic habitats such as stock ponds, springs, improved springs, seeps, wells, and guzzlers. The locations and sizes of willow bottoms and aspen bottoms have been mapped by UDWR on furbearer and moose maps (Utah Division of Wildlife Resources in preparation a,h). BLM has data on the condition of riparian habitat along all streams on BLM lands. This information includes measurements of pool:riffle ratios, areas of various types of substrate, percentage of the stream that is shaded, and cover of streamside vegetation (Ryan 1976, USDI Bureau of Land Management n.d.). The BLM has also maintained a livestock exclosure along Big Creek in Rich County since 1970. Riparian vegetation, water quality, stream-bottom habitat quality, fish production, and terrestrial wildlife use have all been studied as riparian habitat recovered from grazing. Riparian vegetation and stream-bank stability were re-evaluated after trespass reintroduced grazing to the exclosure in 1974 (Duff 1978). Wetlands adjacent to Bear Lake subject to Corps of Engineers jurisdiction under section 404 of the Federal Water Pollution Control Act, with the exception of the Bear Lake National Wildlife Refuge, have been mapped by ACE (Schonholtz 1978).

Small Game Mammals. UDWR is the main source of the limited data available on small game mammals. Cottontail rabbits were included in annual upland game harvest reports in 1969 and later years (Nish 1969, Bunnell and Leatham 1980, Leatham and Roberson 1981); the reports give numbers taken and hunting pressure data on a county-wide basis as is done for upland game birds.

Additional information on small game mammals appears to be restricted to incidental observations and brief discussions in planning and environmental documents.

Nongame Mammals. There is very little information on nongame mammals in the study area. Theses on taxonomy and distribution of mammals, based on the results of trapping in parts of the study area have been done at the University of Utah at Salt Lake City (Rasmussen 1958, Jensen 1965). Museum collections are the other source of nongame mammal information; the largest is at the University of Utah. The BLM has some data from trapping projects done in riparian areas (USDI Bureau of Land Management n.d.).

Nongame Birds. USU, UDWR, and USFS have relatively little information on nongame birds. USU data appear in theses, most of which were done in locations peripheral to the study area, but Winn (1976) studied non-game birds and their relation to several coniferous forest habitats using variable radius plots on the north slope of the Uinta Mountains. Shorebird feeding areas, staging areas, rookeries, and sightings outside the normal breeding areas are being mapped on UDWR overlays (Utah Division of Wildlife Resources in preparation j), but coverage of the study area is incomplete at this time. Bear Lake Regional Commission maps indicate the locations of sandhill crane use areas and great blue heron rookeries in Rich County (Bear Lake Regional Commission n.d. b). The Nongame Section of UDWR has prepared a habitat matrix for nongame birds which could be useful for predicting species occurrence in particular habitat types (Walter 1981).

Nongame Fish. Most of the information on nongame fish is from USU and UDWR. Occurrence of nongame fishes is included in UDWR computer printouts (Utah Division of Wildlife Resources n.d.) discussed above under game fish. A number of theses on nongame fish have been done at USU, but most were done outside the study area. Williamson (1970) studied the Bear Lake sculpin as master's degree research. Workman (1963), and Loo (1960) studied the ecological relationships of various fishes and habitats at Bear Lake. The study of the taxonomy of endemic Bear Lake whitefishes by White (1974) also yielded data on the distribution of whitefishes in the lake.

Reptiles and Amphibians. Only one document on reptiles and amphibians was encountered. This UDWR report contains a habitat matrix (Schwinn and Minder 1979). Additional discussions of herpetofauna appear occasionally in environmental and planning documents.

Land Use Planning/Conflicts. A large part of the information discussed above has been used for planning. The BLM and USFS, which are the primary federal land management agencies in the area, each have planning documents available. The BLM documents are the Randolph Planning Unit Grazing Management Environmental Statement, the Unit Resource Analysis, and the Management Framework Plan. The BLM documents concentrate on the relationships between grazing and wildlife, but also recommend strategies for wildlife management relative to other land uses including oil and gas development. The Wasatch-Cache National Forest is in the process of completing its Forest Plan,

and planning documents are available which discuss the current state of wildlife management on a Forest-wide basis including targets and objectives for the future (USDA Forest Service 1982). The Wasatch-Cache has also prepared two Environmental Assessments for oil and gas development on the Forest, one of which covers the north slope of the Uinta Mountains (The Environmental Management Planning Organization 1982). Local agencies have obtained wildlife planning information from UDWR and BLM in the form of maps (Bear Lake Regional Commission n.d. a,b,c) which in some cases, such as raptors and shorebirds, is more complete than the maps currently available from UDWR. Consulting firms have also supplied qualitative wildlife information for particular projects (Mountain West Design n.d., Bingham Engineering 1982, J.J. Johnson & Associates 1982).

The best information on conflicting land use has been produced by BLM and concerns livestock-fishery/riparian conflicts. The conflict has been particularly well documented on the enclosure along Big Creek in Rich County (Duff 1978). The conditions of other streams on grazing allotments are documented in the Randolph Grazing Management Environmental Statement. The UDWR fisheries computer printouts and maps show stream sections which have been dewatered (Utah Division of Wildlife Resources n.d., Utah Division of Wildlife Resources in preparation g). An additional UDWR map (Utah Division of Wildlife Resources in preparation k) shows "conflicting developments," but none are mapped in the study area. Other conflicts have been briefly addressed in environmental statements.

Wyoming

Big Game. Big game occurring in the Wyoming part of the study area include mule deer, elk, moose, pronghorn, black bear, and mountain lion. Information on big game has been collected by the Wyoming Game and Fish Department (WGFD) with contributions from BLM and industry. Information has been reported for single species and species groups.

WGFD has prepared annual big game reports for ungulates as a group. These reports have been prepared for each Data Analysis Unit (DAU) within Game Management Area IV, encompassing all of southwestern Wyoming. Some data in these reports are broken down by hunt areas, which are a subdivision of DAUs. Since 1975 the reports have had a standard format, although it is rare to find an annual report including complete information for each species. The reports include data on: pre-hunt or post-hunt sex and age ratios and age characteristics of harvested animals; herd population trends; hunter survey questionnaire results and findings at hunter check stations; non-hunting mortality, including illegal kills, road kills, cripple loss, and other accidental deaths; and female reproductive status and fetal development. Recommendations for future harvest quotas and population projections are provided for the entire DAU. Data Analysis Unit Status Reports filed at the WGFD Planning Division office in Cheyenne contain annual reports, as well as the following information: management objectives projected to 1986, ONEPOP and POP50 (computer simulation models) projections of populations and sex and age ratios, general vegetation and habitat descriptions for herd unit areas, land

occupancy status, species distribution maps on seasonally used ranges, herd unit consumptive value statistics, 1971 to 1981 hunt season structure summaries, damage claim reports and actions taken, old data, and other miscellaneous information. While herd unit completion reports are prepared once a year, POP50 simulation models are updated as new data are available.

Information on big game distribution, habitat use and population parameters is stored in computer files through WGFD's Wildlife Observation System (WOS). Recently, WGFD personnel have increased efforts to document big game occurrence, distribution and habitat use in the study area (Base and Pivonka 1983; Base 1983). All observations are recorded on the WOS. A WOS printout for a portion of the study area dated March 24, 1982 listed one observation of mountain lion, 24 of elk, 126 of moose, 953 mule deer and 169 pronghorn observations. Game birds, furbearers, and nongame wildlife observations are also entered in the WOS.

The WGFD final report from the OIA-sponsored Bear River Divide study (Base et al. 1983) provides a more detailed account of big game winter range and transitional range distributions. The data include frequency of winter and transitional occurrence by range habitat type, by distance from various human activities, and in relation to snow depth, elevation, slope, and aspect.

Maps for big game management are available from several sources. WGFD has mapped seasonal distributions within each DAU, indicating the boundaries of critical winter range, general wintering areas, summer range, year long range, areas having no occurrence, and elk calving areas. Migration routes are also mapped. BLM (McCuiston 1981 to 1982) has mapped big game winter locations by aerial surveys in an area extending from I-80 to the Bridger-Teton National Forest (BTNF) boundary which generally coincide with general winter range and critical winter range on WGFD maps. Mountain lion distribution has been mapped on a state-wide basis by Berg (1981).

The BLM has produced two types of vegetation maps used for wildlife management. General vegetation maps at a scale of 1/2 inch to the mile were prepared for the Kemmerer Unit Resource Analysis. A vegetative cover inventory is underway north of US Highway 30 (USDI, in preparation) designed to map areas on the basis of vegetation structure rather than biomass, using USFS methods (Steele et al. 1977). The mapping is being done on overlays to 1:24,000 orthoquads. Approximately ten percent of the area has been verified on the ground. Plans for 1983 are to extend mapping to Amoco's sulfur haul road. A number of habitat evaluation and use monitoring studies have been conducted in the study area by WGFD personnel.

Mule deer have been studied more than the other big game species in the study area. Aerial surveys of wintering deer in the western part of the study area were done from 1976 to 1979 (Lockman 1976 to 1979). Mule deer have been subjected to a number of tagging and collaring efforts over several years. Hunter tag returns and observations of collared or tagged deer appear in a number of reports showing two points, perhaps separated by several years,

in a deer's life movements. Only one doe has been outfitted with a radio transmitter and relocated on multiple occasions by WGFD personnel. WGFD personnel collected 350 observations of unmarked deer in 1981 in the vicinity of oil and gas operations at Painter Reservoir, Clear Creek, and Ryckman Creek. Distance to nearest roads and drill pads were noted along with sex, age, and habitat. The observations were entered into the Wildlife Observations System, but no conclusions have been reached about the effects of roads and well pads on deer distribution. Elsewhere in Wyoming, Hiatt and Baker (1981) attempted to document the influence of oil and gas development on deer and elk, but were unable to form conclusions. One study of food habits of deer and elk, done near Cokeville, was found.

Information on elk was found in other WGFD reports and one USFS memo. Tagging or telemetry projects were done in the area in 1970, 1971, 1975, 1977, and 1978. Tag return data from 1958 to 1963 is on file at the WGFD Green River District office. Aerial and ground counts by WGFD during 1977 and 1978 in the west Green River area resulted in a comparison of mild and normal winter ranges. Other WGFD reports indicate that winter movement between Wyoming and Utah occurs. Two separate accounts by observers in the BTNF during seismic surveys indicate that elk showed a significant hiding response to approaching helicopters (Lockman 1977d, Mooney 1981). Johnson and Lockman (1981) provided a more detailed account of elk response to well drilling in the Snider Basin, west of Big Piney.

Moose studies, beyond WGFD annual reports on population status, are limited to two tagging projects. One of these, including a single animal, was south of US Highway 30. The other study was north of US 30 and east of Cokeville, and involved two animals. No relocation data are available for any of these animals.

Pronghorn data, supplementing DAU reports, have been collected by both WGFD and industry. The Cumberland Coal Company, FMC Corporation, and Kemmerer Coal Company have counted pronghorn, demonstrating variability in population and habitat associations on the areas of their respective mine sites. Observations of pronghorn in the vicinity of coal mines and access roads elsewhere in Wyoming indicate habituation to disturbance although there is some avoidance (Segerstrom 1982, Reeve 1982).

Mountain lion and black bear data are limited to sporadic sightings and harvest reports.

Game Birds The amount of information available on game birds varies by species. The primary sources are WGFD, industry, and BLM for sage grouse; WGFD and UW for waterfowl and WGFD for upland species. Information on sage grouse and waterfowl is extensive, but little information is available on other upland species.

WGFD has annual reports on upland game birds since the 1950's. They were standardized in 1975 as "Annual Game and Small Game Completion Reports" summarized for Green River Management Unit IV. Sage grouse lek counts have been

reported since 1959 consisting of strutting ground statistics for the entire Management Area (June et al. 1981, Moody et al. 1980). Hatching data, brood production, harvest data, and harvest composition are summarized. Moody and June (1977) provide data on individual leks, unlike other annual reports. The reports contain information on other species, such as numbers and sex and age ratios of the harvest, hunting pressure and success, and harvest trends. Brood production data for blue grouse are presented in some cases. During a 1983 OIA-sponsored survey, WGFD recorded lek attendance on 51 leks within the study area (Base et al. 1983). Additional observations of sage grouse document occurrence by habitat type and in relation to elevation, snow depth, slope and aspect from December to March 1983.

Data on waterfowl are presented in WGFD waterfowl reports. The annual reports contain results of aerial surveys of breeding pairs on the Bear River, banding projects, and harvest data on ducks and Canada geese (Serduick and Saul 1981, Saul 1979, Serduick 1979). The data are presented for the Bear River floodplain in the case of Canada geese, and as Wyoming totals (Wrakestraw et al. 1972, Wrakestraw 1970), by county, or for the western part of the state for ducks (Wrakestraw et al. 1971, Serduick and Saul 1981). Sandhill crane inventories on the Bear River and attempts to control crane depredation by providing lure crop fields are described in special reports (Serduick 1970, 1974, 1978, 1980). Additional information on waterfowl is on file with WGFD Migratory Bird Biologist David Lockman in Smoot, Wyoming. Raw data on file include: inventories of nesting areas and numbers of breeding pairs of Canada geese on the Bear River and Smiths Fork, marking data and distribution of geese around Woodruff Narrows, duck counts on the Bear River and beaver ponds, aerial surveys of duck and goose nesting from 1969 to present, brood surveys, and fall counts of sandhill cranes on the lower Bear River. Finally, several theses from UW analysed the effects of nesting structures on goose production in the Bear River flood plain (Appel 1971, Saul 1971, Bone 1973).

Maps of gamebird resources have been prepared by WGFD, BLM, and industry. WGFD maps show sage grouse breeding complexes in the study area on 1:500,000 and 1/2 inch to 1 mile overlays. Similar data appear on BLM's Oil and Gas Stipulations overlay (USDI Bureau of Land Management n.d.) for the Kemmerer Resource Area (scale 1/2 inch equals 1 mile). Berry (1982) has mapped leks on the Cumberland Coal Company's South Haystack mine site, including four leks that were not documented on the BLM map.

Comprehensive sage grouse information is available for the Peter Kiewit Sons South Haystack mine site. A long-term study to determine sage grouse response to mining and mine restoration began in 1979 with lek monitoring, brood counts, trapping, marking, and radio telemetry. The radio telemetry enabled researchers to find nesting hens and accurately determine movement during winter, breeding, and brooding periods (Berry and Eng 1979, 1980, Berry 1981).

Endangered Species Data on endangered or rare species can be obtained from the FWS, The Nature Conservancy, BLM, WGFD, and industry. The level of data varies from very little to fairly complete. The best single source of

information on endangered species is The Nature Conservancy's Wyoming Natural Heritage Program (WNHP), which has data on rare and endangered species occurrence in Wyoming on computer files.

The FWS has data on black-footed ferrets, peregrine falcons, and bald eagles. FWS reports document searches for ferrets in an area north of Kemmerer and along the Uinta-Lincoln county line (Martin and Schroeder 1981, McDonal and Schroeder 1981). Both Lincoln and Uinta counties were surveyed for peregrine falcons in 1979 and parts of the counties along the Green River were surveyed again in 1980 (Jenkins 1979, 1980). A report by the FWS incorporates the results of both the Midwinter Bald Eagle Count and studies conducted on the Woodruff Narrows bald eagle roosting area (Jenkins 1982). The report includes count data from November 1980 to March 1981 and February and March 1982, age ratios, food habits, habitat use, and behavioral observations including reaction to disturbance. Some individuals were trapped and outfitted with radio transmitters.

The WNHP lists seven species of fish as endangered, rare, or of unknown status. All are classified as "unknown status" by the FWS. The leatherside chub and the flannelmouth sucker are of common status in Wyoming. WGFD (Binns 1977, 1981) has prepared reports on the purity of cutthroat trout populations.

Reports and files of WGFD contain data on several endangered species. WGFD provides bald eagle counts during the winter of 1983 for the Woodruff Narrows roost and for the entire Bear River Divide (Base et al. 1983). General habitat associations of wintering bald eagles (December through March) are also reported. Two sightings of peregrine falcons were documented during the 1983 WGFD Bear River Divide study (Base et al. 1983), confirming the presence of this species within the study area. WGFD surveyed prairie dog towns on the Cumberland Flats in 1983 with negative results (Base et al. 1983). Sightings of whooping cranes are documented in the files of Dave Lockman; a ringtail was collected north of Kemmerer (Clark and Dorn 1981); wolverines have been seen in the general area (Lockman 1976; Clark, personal communication).

Industry provides more site-specific data. The area surrounding the Cumberland Coal Company's South Haystack mine site was searched for black-footed ferrets in 1978 and 1979, resulting in discovery of skeletal remains (Martin and Schroeder 1979, 1980). Clark and Campbell (1980), Martin and Schroeder (1981), and McDonal and Schroeder (1981) have also conducted searches for black-footed ferrets in the study area, but no conclusive results indicating ferret presence were obtained.

Furbearers. Data on furbearers are limited and have been collected primarily by WGFD and BLM. Opportunistic sightings of furbearers have been made by FWS and industry personnel. Drainage summary data from the Rock Springs District BLM office include beaver pond numbers, size and depth, pond siltation and water quality, activity status and fish blockage. WGFD Fish Division files provide information on historical beaver dam locations by

stream and stream reach. Hollings and Berry (1980) surveyed ponds for mink, beaver, muskrat, and striped skunk in their survey of standing waters and wetlands for BLM's Kemmerer Known Recoverable Coal Resource Area. Strickland (1978b, 1980, 1981) provides state-wide data on bobcat harvests including numbers and ages taken, reproductive information, and estimates of densities by vegetation types. The locations of bobcats harvested in the 1980-1981 trapping season are plotted on a 1:500,000 state-wide map. Base et al. (1983) provide observations of beaver, muskrat, coyote, red fox, ermine, long-tailed weasel, badger, striped skunk, and bobcat within the Bear River Divide. These observations are stored on the WGFD Wildlife Observation System.

Game and Nongame Fishes. Miller (1977) and Remmick (1981) distinguished between the native cutthroats (Colorado River and Bonneville) and the Snake River (fine-spotted) cutthroat which has been introduced. Neither investigation distinguished those big-spotted varieties from the big-spotted Yellowstone cutthroat which was widely introduced during the first half of this century.

Fish inventories are provided in a variety of WGFD Fish Division reports, files, and data bases. The stream, lake, reservoir, and farm pond data base contains information on stream characteristics, public use and availability, management plans and procedures, and fishes known to occur (for up to 30 species). Much information is contained in field data from stream surveys and lake surveys on a county by county basis. Since 1957, annual progress reports have been published by the WGFD Fish Division listing current projects undertaken and completed. These provide game and non-game fish population estimates, fisheries types (e.g. basic yield vs. wild), sampling techniques, management suggestions, spawning operations, habitat quality control, habitat alterations, USFS Coop Native Cutthroat Study operations, industry permits and involvements, discharge permits, pollution, spills, Federal, state and private water land use projects, stream dewatering and public relations.

BLM has conducted stream inventories. Hollings and Berry (1980) describe fisheries potential for separate standing waters in the Kemmerer Known Recoverable Coal Resource Area.

Raptors. Raptor occurrence in the study area has been documented by WGFD, BLM, FWS, and private industry. Raptor species known to occur are documented in Oakleaf et al. (1982) for degree block 22 (including all of Uinta County and the southern half of Lincoln County). Nest sites of golden eagles, buteos, accipiters, falcons, and owls in the study area have been mapped on state-wide overlays (scale 0.5 inch to 1 mile) by WGFD. BLM (USDI 1981) as well as private industry (Berry 1982) have also prepared raptor maps. WGFD recently surveyed the study area for nesting raptors and documented 5 species nesting within the study area (Base et al. 1983). Habitat association information for wintering golden eagles and rough-legged hawks is also reported in this study. A recent raptor inventory conducted by FWS (Phillips 1982) documented nest sites in the study area. Both WGFD and BLM have documented raptor nest locations and activity status for the eastern part of the study area. WGFD has photographed each nest site. A long term raptor

nest monitoring study was conducted on the Cumberland Coal Company South Haystack Mine area (Berry 1982). Ten species of raptors were monitored for nest activity and nesting success from 1977 to 1980. BLM is conducting a study on nesting golden eagles to assess impacts of road construction and use. Radio telemetry is being used.

Riparian/Aquatic Habitats. Riparian areas have been mapped by BLM and described in environmental assessment records and environmental statements. Rather limited qualitative and quantitative information is available for riparian and aquatic zones.

Hollings and Berry (1980) evaluated standing waters and wetlands for the study area. During 1980, 299 ponds within the Kemmerer Known Recoverable Coal Resource Area (KKRCRA) were surveyed for limnologic characteristics, non-waterfowl birds, fisheries potential, furbearer occurrence, and big game and livestock use.

Drainage summary data on riparian habitat from the BLM Rock Springs District Office are available for some streams, documenting acreage, condition rating, stream channel stability, stream habitat trends, spawning habitat, and fish habitat.

WGFD biologist David Lockman is currently mapping vegetation within the Bear River flood plain using 1:24,000 aerial photographs. This project should be completed in 1983.

WGFD Fish Division has records of streams surveyed within Lincoln and Uinta Counties. The dates of these surveys vary. Some streams have been surveyed only once, while others have been surveyed repeatedly. The types of information include: stream accessibility, average water volume and current, stream gradient, average maximum depth, temperature, water chemistry, percent riffles and pools, barriers, springs, bottom characteristics, descriptive character of the watershed, plants observed and pollution records. Similar field data exist for lake surveys conducted in Lincoln and Uinta Counties. BLM has proposed a riparian fencing project on the Woodruff Narrows due to unmanaged grazing and soil compaction resulting in bank erosion.

Small Game Mammals. There is relatively little known about small game mammals inhabiting the study area. WGFD (1977a) lists four species present in the area (Findhold et al. 1981): desert cottontail, Nuttall's cottontail, snowshoe hare, and red squirrel. WGFD management objectives are to maintain or increase current populations (Wyoming Game and Fish Department 1978a). Projections to 1983 indicate increased hunter demand based on 1973 to 1980 hunter use (Wyoming Game and Fish Department 1978b, 1982b).

A recent WGFD printout of the Wildlife Observation System (computerized data base) for a portion of the study area lists 67 observations of desert cottontails and 12 observations of Nuttall's cottontails from 1978 to 1981. Cottontail density data have been gathered from roadside counts for at least 16 years and translated to animals per mile and animals per square mile (June

1971, June et al. 1981). The WGFD reports for District IV summarize these density trends for Lincoln and Uinta counties. Harvest data for cottontails, snowshoe hares and red squirrel are summarized by county.

Information is available from Cumberland Coal Company's South Haystack Mine wildlife studies (Berry 1982). Flush transects and night spotlight surveys provided information on density and habitat use for white-tailed jack-rabbits and cottontails. Other reports provide incidental observations (Martin and Schroeder 1979 and 1980; Morrison Knudsen Company 1981; Stoecker 1981). Pygmy rabbits have been found south and west of Kemmerer (Morrison-Knudsen Company 1981; Base et al. 1983; Clark, personal communication).

Nongame Mammals. Of the nongame mammals occurring in the study area, the white-tailed prairie dog has been best documented, at least for distribution and evaluations of prairie dog towns. FWS personnel have conducted prairie dog town surveys and mapped towns in the vicinity of Cumberland Coal Company's South Haystack Mine (Martin and Schroeder 1979, 1980). Two towns east of Woodruff Reservoir were mapped during 1980, one town five miles north of Kemmerer was searched though no map is available (Martin and Schroeder 1981). Town acreage and number of holes for each of 18 prairie dog towns surveyed is provided in Berry (1982). McDonal and Schroeder (1981) provide maps of prairie dog towns along the Mapco Pipeline route near the Lincoln-Uinta County line. WGFD has summarized some of this information, and mapped other towns not covered by FWS surveys at a scale of 1:500,000; the map has not been updated since 1979. Prairie dog towns have been mapped on FMC Corporation's Skull Point Mine and at Pittsburg and Midway's Kemmerer Mine. Finn and Rothwell (1977) surveyed prairie dog towns within T16N to T19N and R116W to R118W. These data are in raw form, but include town location, number of holes per acre, acreage of the town, and general vegetation types. No prairie dog surveys have been undertaken outside of the areas mentioned with the exception of the two towns in Rich County, Utah.

Rodent populations have been studied on several coal lease areas in the eastern portion of the study area. Live trap grids have been used on the Cumberland Coal South Haystack Mine area, the FMC Corporation Skull Point Mine, and Pittsburg and Midway Kemmerer Coal Mine (Berry 1982, Stoecker 1981, Morrison-Knudson Company 1981). Where sufficient recapture data were available, Berry (1982) calculated deer mouse densities and population estimates. Relative mammalian species abundance by general habitat type in the study area is reported by Base et al. (1983).

Researchers from Utah State University are investigating rodent granivory and shrub cover effects on rodent populations in the vicinity of the Kemmerer Mine site (Innis and MacMahon 1982). This study is to continue through 1983. BLM is conducting a small mammal trapping study, which should be correlated with vegetative community data, within the Kemmerer Known Recoverable Coal Resource Area following Belitsky's (1981) work on the Salt Wells-Pilot Butte Planning Unit.

Nongame Birds. Nongame birds have been documented by state and federal agency personnel and private individuals in the study area. Oakleaf et al. (1982) provide a species by species account of seasonal status, reproduction and feeding life form, abundance category, and occurrence by habitat type. During a more intensive survey on the study area, WGFD documented eight new records of bird species occurring within degree block #22, (Base et al. 1983). Relative species abundance by habitat type is also noted. Dorn (1978) provides historical references for bird occurrence in southwestern Wyoming and estimated densities of birds by BLM vegetation type. The FWS (1967) has published a species list for birds at the Seedskaadee National Wildlife Refuge. These lists are gross indications of nongame bird occurrence on or near the study area. Two breeding bird survey routes are established in the survey area. These have been surveyed since 1977 by WGFD personnel. Locations of each stop, counts per stop, and habitat types per stop are on file at WGFD District IV offices in Green River. Sightings are placed in the WGFD Wildlife Observation System. Other bird inventories have been conducted by FWS during surveys for black-footed ferrets in the Cumberland Coal Company South Haystack mine area. Mr. Craig Kesselheim from Evanston has provided bird species lists from his personal field notebook for 1981 to 1982. He provides dates, locations and various comments on breeding and other activities. Many of these observations are the only ones available for the west slope of the study area, especially for the Bear River valley north and south of Evanston.

Three studies provide nongame bird data that involves some analysis of habitat associations. Personnel with Peter Kiewit Sons/Cumberland Coal Company South Haystack mine conducted bi-monthly flush transects from December 1977 to December 1978 and belt transects were sampled in June of 1976 and 1982 to determine breeding bird species density and community diversity (Berry 1982). Fitton (1982) lists ten species nesting only in Utah juniper communities in Wyoming and provides an argument for the unique qualities of that habitat type. The Morrison-Knudson Company (1981) prepared similar bird documentation for the FMC Corporation's Skull Point Mine south of Kemmerer.

Hollings and Berry (1980) provide shorebird and passerine data on and around standing waters and wetlands from Pomeroy Basin north of Kemmerer to Sulphur Creek Reservoir southeast of Evanston. This report and its appendices contain substantial data that could be used for comparison.

BLM has conducted nongame bird transects for species occurrence and relative abundance in the KKRCRA. These data are presently in raw form. Mr. David Lockman has conducted counts of long-billed curlews, white-faced ibis, snowy egret, black terns, bitterns, and black-crowned night herons in the lower Bear River area. Some of these species nest nowhere else in Wyoming. Recently, Cochrane and Oakleaf (1982) documented historical sightings of long-billed curlews in the Cokeville area. Lockman (1982) claims the Bear River area near Cokeville provides excellent nesting habitat for this species. The Wyoming Natural Heritage Program search provided three records of nesting long-billed curlews in 1981 and 1982. Mr. Kesselheim also reports curlews on the Bear River.

Reptiles and Amphibians. Amphibians and reptiles in the area are the least studied vertebrates. According to Baxter and Stone (1980) five species of amphibians and four species of reptiles are likely to be found. Clark and Dorn (1981) list the northern tree lizard as rare and a possible inhabitant of extreme southwestern Wyoming. One sighting of a Great Basin rattlesnake has been reported west of the Bear River and Baxter and Stone (1980) list this species, as well as the western yellowbelly racer, as possibly occurring in Uinta County.

Inventories of local herpetofauna have been made concurrently with black-footed ferret surveys in the vicinity of Cumberland Coal Company's South Haystack mine site during 1978 and 1979 (Martin and Schroeder 1979, 1980). Berry (1982) documents additional herpetofauna on the South Haystack study area. Two reports from the BLM (USDI Bureau of Land Management 1978b, 1979) add several species not listed by Baxter and Stone (1980) to the area list. No population or distribution data have been gathered for herpetofauna in the study area. BLM provides density estimates in various habitat types on the North Block and South Haystack proposed mine lease areas (BLM 1978).

Land Use Planning/Conflicts. WGFD big game DAU Status Reports identify specific concerns or land use conflicts including big game interspecific competition, big game/livestock and big game/industry problems. Sex/age composition counts, population trend counts and ONEPOP population simulation models are used for population projections and setting harvest levels and regulation. Damage claims and actions taken are also included in these status reports. WGFD enforcement personnel maintain records of illegal harvest and arrest information.

WGFD overlays for each big game DAU identify seasonal range use areas and critical period areas for each species. Likewise, state-wide overlays for bald eagle winter roost and nesting areas, potential areas of black-footed ferret occurrence, upland game bird strutting grounds, and raptor nesting areas are used to identify sensitive areas for these species. BLM has produced composite overlays and maps using WGFD information. These are the basis for defining oil and gas development stipulations within a given area. The Wyoming Oil and Gas Commission also uses WGFD information in its siting regulation procedures. BLM has not yet prepared a grazing environmental statement for the Kemmerer Resource Area/Pioneer Trails Planning Unit. However, this statement is being prepared and may be available by 1984. Conflicts between wildlife and coal and oil/gas industries have been addressed in several documents (USDI Bureau of Land Management 1978a, 1979, 1980, 1981).

WGFD Fish Division has identified stream alteration projects needing rehabilitation. Various problem areas are identified in administrative and annual progress reports. Fish Division computer printouts contain fisheries management policies for each stream in the study area. Similar information is available for tributaries to the Bear River (Miller 1977) and to the Green River (Remmick 1981).

Idaho

Big Game. Most information on big game is available from Idaho Department of Fish and Game (IDFG) with supplemental information available from the USFS and BLM. Extensive information is available on big game. Annual big game harvest reports are available from IDFG which include harvest data and rough population estimates for mule deer, elk, moose, black bear, and cougar (Oldenburg and Medford 1982 a,b,c). The data is broken down by management unit (Unit 76 consists of eastern Bear Lake and Caribou counties), and includes estimated numbers, sex, age, and similar information on animals taken and hunting pressure. Annual big game winter survey data is available. IDFG has also completed management plans for these species which forecast future population trends and hunting pressure.

A comprehensive study of the impacts of large-scale phosphate mining is nearing completion just to the north of the study area (Kuck and Merrill 1981, Kuck et al. 1982). The anticipated completion date is 1983. This five-year study has examined population sizes, distribution, movements, and habitat use patterns for mule deer, elk, and moose and has included some areas in northern Bear Lake County. Detailed study of habitat selection has been completed, as well as projection of the actual effects of mine activity on distribution and habitat use (Merrill 1981), elk calf survival, and deer migration. A computer program (PATREC) which predicts the habitat potential of a given area for mule deer and elk summer and winter range, and moose year-round range has been developed for the phosphate study area (Evans 1982, Kuck 1981). Another computer program (MANALT) that evaluates the suitability of different management alternatives for wildlife is currently being completed (Evans 1981). These programs could be adapted to evaluate habitat potential for the respective species within Bear Lake County. Findings and research conclusions from the IDFG phosphate study can be applied to oil and gas development in the area with a minimum loss of resolution.

Range inventories and various range-utilization transects have been conducted over the years. Maps of big game habitat are available from IDFG, USFS, and BLM. Map resolution and detail vary, and discrepancies exist between maps. Vegetation types have been evaluated from LANDSAT imagery (Kvale 1982).

Aspen forests within the area provide highly preferred big game habitat. The expansion of Intermountain Forest and Range Experiment Station (USFS) aspen research by IDFG has concluded that natural succession from aspen to conifer and brush habitat may have a more significant negative impact on big game than industrial development (Evans 1982, Hemker 1982). USFS has initiated aspen regeneration studies of controlled burns, spraying, fuelwood sales, and small clearcuts. Aspen habitat improvement may prove an effective way of compensating for some impacts of oil and gas exploration on big game species.

Game Birds. Several sources have extensive information on upland game birds and waterfowl: IDFG, BLM, FWS, and theses and dissertations from the University of Idaho (UI), and Idaho State University (ISU).

IDFG publishes annual harvest reports for upland game birds (Norell 1982), which include extrapolated harvest totals and hunting pressure on a countywide basis. Bear Lake County upland game birds receive low management priority from IDFG, therefore availability of information is limited. IDFG surveys one sage grouse lek annually. BLM and USFS have mapped sage grouse leks and upland game bird distributions. Information on sharptailed grouse is limited, but extensive information is available from similar habitat on the Curlew National Grasslands to the west (McArdle 1977). Habitat information for blue and ruffed grouse is available just to the north (IDFG) and west (UI) of the study area. Stauffer and Peterson (1982) provide keys to habitat suitability for forest grouse. Regional Management Plans (Idaho Department of Fish and Game 1975a,b) are available for upland game and waterfowl. Other game birds, which include pheasant, chukar, and hungarian partridge, occur in very limited numbers, and there is little information available on these species.

Extensive waterfowl nesting occurs on the Bear Lake National Wildlife Refuge. Nesting surveys which determine the number of pairs and nest success of Canada geese and ducks are made on the refuge and in nearby areas. Aerial counts of Canada geese, sandhill cranes, and ducks are made in summer and fall in cooperation with IDFG. Harvest data is recorded on some sites. A plan for acquiring redhead duck nesting habitat, including areas in Bear Lake County, has been prepared by FWS (1981).

Endangered Species. Information on endangered species is available from IDFG, FWS, and USFS. Bald eagle surveys have been conducted in Caribou and northern Bear Lake County (Kuck et al. 1979). Data from the annual Mid-Winter Bald Eagle Survey is available from BLM. Potential peregrine nest sites, including a historic nest site near Montpelier, were surveyed in Caribou and Bear Lake County (Kuck et al. 1979). Expansion of range into Bear Lake County by reintroduced peregrine falcons and whooping cranes is expected. Long-range expansion by grizzly bears, wolves, and trumpeter swans is not expected.

Furbearers. IDFG is the primary source for furbearer data. Harvest reports are published annually and include estimates of numbers harvested by county. Population estimates are available only for beaver. Most drainages have been surveyed by USFS and habitat potential and number of colonies assessed. Trend counts are made annually on Montpelier Creek by IDFG, and furbearer reports include numbers of beaver harvested, damage complaints, and qualitative population estimates. Limited data for muskrats are available from FWS. Populations of river otter and bobcats were assessed qualitatively by IDFG during consideration of possible threatened status. Rough maps of their distributions are available. Considerable information is available on coyotes and badgers from theses and dissertations done by USU students at Curlew National Grasslands.

Game Fish. Data is available through IDFG, USFS, and Utah Division of Wildlife Resources (UDWR). Angler surveys and creel censuses have been made

of Bear River and two reservoirs (Heimer 1973, 1974). Stream surveys and electroshocking have been done by IDFG and USFS. Extensive population studies have been done on the endemic Bear Lake cutthroat trout and other lake species (Nielson 1982). Surveys of the endemic and now greatly reduced and potentially threatened Bonneville cutthroat have been made by IDFG and USFS (Wallace 1978 a,b). Habitat has been surveyed in light of interactions with livestock grazing and beaver colonies. Some stream habitat has been improved through fencing and structural improvements by USFS. Harvest data (Utah Division of Wildlife Resources 1980c) and economic analysis (Keith 1971) is available for the endemic Bonneville cisco in Bear Lake. Some information is also available for the endemic Bear Lake and Bonneville whitefishes (White 1974).

Raptors. Limited data is available for raptors. FWS regularly censuses raptors on the Bear Lake Refuge. IDFG has censused raptor species (Chase 1979) and prairie falcon nests in Caribou County adjacent to the study area. Nesting surveys of accipiters have been done nearby (Chase 1979, Hennessy 1978). USFS has a planning report on raptors and land use (Benson 1976). Information on ferruginous hawks in similar habitat is available from USU for Curlew National Grasslands.

Riparian/Aquatic Habitats. Aquatic habitat data is available from IDFG and USFS. Most information was described under the Game Fish heading. BLM has surveyed condition of riparian habitat along streams on BLM lands. Wetlands associated with Bear Lake Refuge have been surveyed and assessed for value as waterfowl nesting habitat by FWS. Extensive data on water quality and aquatic invertebrates in Bear Lake have been collected (Nyquist 1967, Nunan 1972, Somerville 1975).

Small Game Mammals. Only limited data is available from IDFG on harvest of cottontails. Blacktail jackrabbits have been studied extensively in similar habitat at Curlew National Grasslands.

Nongame Mammals. Little information on nongame mammals is available. Nongame mammals have been surveyed in adjacent Caribou County (Winn 1976, Kuck 1979, Rubright 1980). A habitat matrix is available from IDFG for all mammals, broken down by vegetation type and season, and it could be useful for predicting occurrence.

Nongame Birds. Relatively limited data has been collected on nongame birds. Marsh and shorebirds have been surveyed intensively at Bear Lake Refuge by FWS. The surveys include sandhill cranes and colony nesters such as great blue herons, white-faced ibises, gulls, and terns. Nesting success data is available for some. A habitat matrix is available from IDFG for all nongame birds, broken down by vegetative type and season. Nongame birds have been surveyed in Caribou County north of the study area (Winn 1976, Kuck 1979, Rubright 1980). Isolated records on BLM lands are available, especially for sensitive species such as long-billed curlews.

Nongame Fish. Limited information on nongame fish is available from Bear Lake (Workman 1963, Nielson 1982).

Reptiles and Amphibians. IDFG and BLM (Wilson 1975) have habitat matrices for reptiles and amphibians.

Land Use Planning/Conflicts. Much of the above information has been used for planning. The BLM and USFS are the primary land management agencies in the area and each has planning documents available. BLM documents include Bear Lake Planning Unit Resource Analysis and Caribou-Bear Lake Management Framework Plan. The Caribou National Forest has completed a Draft Forest Plan including a section on Fish and Wildlife Resources, the Bear River Planning Unit, Environmental Statement and Land Management Plan, an Environmental Analysis Report for Oil and Gas Leases, an Environmental Assessment for Geothermal Leasing, an Environmental Assessment for Diamond Creek Aspen Management Unit, and Caribou N.F. Travel Plan (1981).

Both BLM and USFS have data on livestock-fishery/riparian conflicts. Illegal hunting has been documented by IDFG. Other conflicts have been briefly addressed in various environmental statements. IDFG has reviewed impacts of surface mining on big game (Wood and Merrill 1979). Hupp and Connelly (1982) assessed impacts of transmission lines on avian species. Peek (1979) and USFS (1981b) have reviewed problems of increased vehicle access. USFS (1978, 1981a) has reviewed problems of oil and gas exploration and geothermal development.

FINDINGS - INFORMATION GAPS

This section discusses information gaps and anticipated problems in applying local knowledge to wildlife management in oil and gas development areas. The discussion centers on management needs for planning and impact assessment. Further discussion of information gaps can be found in the "Recommendations" section of this chapter and in the final chapter of this report.

Utah

Big Game There are both gaps and anticipated application problems for big game information. Most data on big game are herd unit or county-wide in scope. For site-specific planning, higher resolution would be required. Oil and gas development may not cause impacts large enough to be measured against data of this level of resolution. Planners will not be able to make full use of the available data, but will have to rely heavily on maps. In addition, there appear to be some gaps in information on fawning or calving habitat for big game species. Antelope have recently expanded their range into the Crawford Mountains but there is no data on this population.

Game Birds. Information on game birds is incomplete. Sage grouse, which appear to be the most sensitive game bird in the area, are well understood relative to other species. However, all leks are probably not located and/or accurately mapped. The resolution of maps for brooding and winter range is not at a high enough resolution for site planning and impact assessment. Level of resolution also limits the value of maps for management of other upland species. Data on sensitive and productive waterfowl habitat are lacking.

Endangered Species. Data on endangered species are incomplete for all potentially present species except the bald eagle and peregrine falcon. Data on black-footed ferrets are confined to the results of multi-state sighting compilations and undocumented accounts of possible sightings. There are apparently no maps of suitable scale showing either possible sightings or potentially suitable prairie dog towns. Habitat suitable for future expansions of whooping crane migratory or breeding range has not been identified.

Furbearers. Information on furbearers other than beaver is incomplete. There does not appear to be any data on canid or felid species (with the exception of lynx) or muskrat within the study area. Data on lynx, marten and otter is limited to general habitat mapping (coniferous forest). Information on beaver appears generally adequate but the resolutions and nature of harvest and population data varies.

Game Fish. Game fish data is reasonably complete, particularly for stream habitats. Fishery data for lakes and ponds appears to be adequate. Livestock - fish interactions are not well documented on most streams in the study area.

Raptors. Raptor data is reasonably complete for common and highly visible species and for endangered species such as the eagles, larger falcons, and great horned owl. Nest inventories are not complete for any nesting species. Information on the accipiters, Swainson's hawk, osprey, barn owl, burrowing owl, and great gray owl is generally lacking. Similarly, information on very common species of lesser interest, such as kestrels, marsh hawks, and the other small owls is generally not available.

Riparian/Aquatic Habitats. Inventories of deciduous riparian habitat are reasonably complete, but inventories of other wetland habitats are not. Plans exist for mapping wetlands adjacent to the Bear River, but the status and start-up dates for these plans are uncertain. Meadow habitat adjacent to smaller waterways appears to be important to sage grouse, but has not been inventoried. The effects of livestock grazing on riparian and aquatic habitats is documented on only a few streams in the study area.

Small Game Mammals. There is data available for cottontail rabbits, and very few other small game species are present in the study area. The data on cottontails is county-wide in resolution. Site-specific planning and impact assessment may require more detailed information.

Nongame Mammals. Information on nongame mammals includes taxonomic studies, distributional studies, and museum specimens. UDWR has apparently not yet compiled a habitat matrix for nongame mammals, which has been done for nongame birds, reptiles, and amphibians.

Nongame Birds. Data on nongame birds is limited and incomplete. Although UDWR is preparing maps of important shorebird areas, coverage has not yet extended to the very productive Bear Lake, Bear River, and reservoir areas. With the exception of USFS planning documents, there does not appear to be any data on the use of nongame birds as ecological and management indicator species.

Nongame Fish. Available data includes occurrence information on UDWR fisheries computer printouts. Data on some species is non-existent. There does not appear to be any data on baitfish introductions and problems that may have been caused by such introductions.

Reptiles and Amphibians. Available information on these taxa is limited to a single predictive document, and there does not appear to be any data that is specific to the study area.

Land Use Planning/Conflicts. Planning information on federal land is reasonably complete or will be completed in the near future. Local planning information appears adequate for qualitative consideration of wildlife values during development, but cumulative or off-site effects are rarely considered. Similarly, information on the effects of land use on wildlife is reasonably complete for federal lands, but not private lands. The interactions of live stock grazing and fisheries and riparian/aquatic habitats are fairly well understood, although only documented on some federal lands. The effects of housing developments and recreational developments on private lands are poorly documented and have been given relatively little consideration.

General Information Gaps. The following items are common to most or all of the species groups discussed above. The level of resolution of most data is not sufficient for site-specific planning and impact assessment. There is also an absence of information on the effects that changing land uses may have on wildlife resources. In particular, there does not appear to be any data on the effects of oil and gas development in the study area. Similarly, although there is some data on the effects of various land uses, there does not appear to be any information on the relative impacts of these uses or their interactions.

Wyoming

Big Game. Information provided in big game reports is at a low level of resolution and is not sufficient for evaluating impacts of local human-related activities. Migration routes, as they appear on DAU overlays, are general movement directions from summer to winter ranges and appear to be based on one or two sequential observations within a given year or evaluation

of several years' observations. Where animals have been marked (mule deer and elk), there are numerous records of tagging locations and observation or harvest sites, but these are in various reports and files and have not been completely mapped or summarized.

Documentation of monthly and seasonal distribution changes is limited; but considerable month to month variation in distribution and habitat use has been observed. In summary, there is no area-wide information on big game movement and the factors responsible. Shifts in distribution and home range as functions of annual cycles, habitat characteristics, local densities, weather phenomena, and water availability have not been documented. The overlap of livestock and big game ranges, while possible to infer on a broad level from allotment records and WGFD DAU distribution maps, has not been assessed.

Game Birds. There is information on sage grouse movements to and from seasonal ranges and specific lek attendance for several years, but this information is localized. The portion of the study area that has been searched for sage grouse leks is not known. No leks have been reported south of I-80. Sage grouse wintering Sage grouse wintering and brood rearing areas are not documented. Annual variation in reproductive success due to environmental factors are not well understood. Other upland game bird species are not well documented.

Long-term data on Canada goose populations, distributions, and use of nesting structures is available. Less is known for ducks and sandhill crane populations in the upper Bear River. Recent discoveries of nesting white-face ibis near Cokeville and nesting of other nongame water-dependent species substantiate the Bear River Valley and its tributaries as important wetlands in the Rocky Mountain region. WGFD personnel are in the process of mapping the lower Bear River flood plain in Wyoming; it is unknown whether or not the upper reaches will receive similar treatment. Many stock ponds on public lands in the Kemmerer Known Recoverable Coal Resource Area (KKRCRA) were documented as having waterfowl use. Ponds on private land and on areas outside of the KKRCRA have not been surveyed. Lands south of I-80 and on the west slope of the study area have not been surveyed for wetlands habitat.

Rare and Endangered Species. The relatively high incidence of ferret skeletal remains found near the South Haystack mine area confirms that black-footed ferrets occurred historically. Additional mapping of prairie dog towns as part of an overall habitat survey may be warranted.

The bald eagle study conducted on the Woodruff Narrows provided insight on bald eagle habitat use, prey use, and behavior. FWS is in the process of preparing guidelines for bald eagle essential habitat based on relocations of birds and subsequent home range determination. No information comparable to the Woodruff Narrows study is available for the Rock Creek winter roost.

The discovery of pygmy rabbits on the Cumberland Flats was a surprise since the area is distant from other pygmy rabbit occurrence in Bannock County, Idaho and Cache County, Utah (Campbell et al. 1982). The status of this species is undetermined in Wyoming. The wolverine, listed as rare in Wyoming, may occur north of the study area but its distribution is also in question. There are no reports of wolverine from the southern Wyoming boundary with Utah. Whooping cranes, while known to be incidental, are unknown as far as potential for nesting habitat in the study area is concerned.

Furbearers. Only some streams and ponds recently evaluated for beaver presence and activity actually contain beaver. Older records of beaver occurrence in WGFD Fish Division files need to be updated. There is no population data or adequate harvest data available. There is less information on muskrats, red fox, badger, weasels, skunks, and coyote. Bobcats are harvested in the study area but locations of specific kills, populations, distributions, movements and reproduction are unknown.

Game and Nongame Fish. WGFD Fish Division files show that many streams and some standing waters have been surveyed. A stream by stream, and pond by pond examination of these files would be necessary to determine which are not surveyed or which surveys need updating.

Stream and pond sedimentation studies are available for some waters, but these too would have to be examined on an individual basis to determine what information has been gathered for areas subject to impact from roads, drill pads, and ancillary facilities of the oil and gas industry. Generally, stream bank degradation as a function of livestock use has not been well documented in the area and this, coupled with other sources of sediments, may be widespread throughout the study area.

Raptors. WGFD raptor nest overlays show that most nests lie along main thoroughfares. When a particular location is closely examined, the density of raptor nests increases dramatically. It appears that most of the study area has not been searched for nests of the species likely to inhabit the area. There are documented nest sites that may not appear on summary maps and these need to be compiled. In the absence of long-term nest productivity and occupancy data, there is no way to determine annual or cyclic fluctuations in raptor use proximate to or distant from oil and gas activities. No information is available on either the extent of a prey base or on use of prey items.

The current BLM study on golden eagle behavior in the vicinity of increased vehicular traffic is valuable. However, without adequate controls, the study results may only offer qualitative accounts of individual response to disturbance.

Riparian/Aquatic Habitats. Standing waters and wetlands have been partially surveyed in the study area. The study area was not included in WGFD's state wide riparian zone surveys and no other accounts of riparian vegetation overstory, understory composition and characteristics, zone length, width,

availability of water and presence of wildlife species and livestock use have been found. Surveys for fish habitat have been done for some streams in the area by BLM and WGFD but these raw data have not been evaluated for the study area as a whole.

Small Game Mammals. There is little data available for species in this wildlife category. Density estimates are available for cottontail and summarized for management units or for counties. The only site-specific monitoring program that examined lagomorph occurrence showed variation on a monthly basis in certain habitats and very little in others. Not all habitats within the study area have been examined. Harvest data are available for red squirrels and snowshoe hare and these are summarized by county.

Nongame Mammals. There have been mammal investigations in the Cumberland Flats area. These studies describe species occurrence and relative abundance and serve as potential sources of local habitat affinities. However, not all habitats in the study area have been investigated.

As discussed previously, it is unlikely that all prairie dog towns have been located, mapped, and examined for activity. Present maps are either for local sites or at such a large scale to be of limited value except to suggest that some information has already been collected in the general vicinity.

Nongame Birds. Breeding bird survey routes have been conducted along major highways along the eastern boundary of the study area. Additional site-specific nongame bird surveys are known for Cumberland Flats and these provide some excellent information for monthly or seasonal habitat associations. These studies might well serve as references for the habitat types encountered. However, the western slope and southern portions of the study area have not been surveyed and bird occurrence, as well as habitat descriptions, are largely unknown. From WGFD's nongame inventories in juniper and aspen stands elsewhere in the state, there have been several species that are documented for only these habitat types. Aspen, juniper, and riparian communities have not been adequately surveyed.

Reptiles and Amphibians Amphibians and reptiles inhabiting the study area have been documented as incidental observations. No efforts to evaluate species range or inventory all species in the area have been found.

Land Use Planning/Conflicts. WGFD data on big game species, upland game birds, and rare and endangered species is summarized for large areas. Graphic displays are at varying degrees of resolution. These data, while adequate for management of an area the size of a DAU or county, are not specific enough to be of value in predicting impacts from a site-specific disturbance such as drill pad. Winter range areas have been delineated for big game, but as several investigations have determined, there is year to year variation in winter range use. Not all sage grouse leks, wintering areas, nesting areas and brood critical areas have been defined. Raptor nest sites and prairie dog towns have not been completely documented and where these species and black-footed ferrets are a concern, information necessary for

site-specific planning and impact assessment may be absent. In general, most wildlife information in the study area is at a level of resolution that limits application to regional planning.

Idaho

Big Game. While information on big game is better than for any other species group, there are both information gaps and anticipated application problems. Most harvest-type data is management unit-wide, limiting its usefulness. Harvest data is limited for Bear Lake County since only one check station has been sporadically operated through the hunting season. The loss of habitat to oil and gas development is site-specific and is not expected to be the primary impact on big game. The resolution of available information is too gross to use for measuring this impact. With the exception of possible application of PATREC models, planning efforts will need to rely heavily on maps. The quality and resolution of these maps are variable, but they do show important wintering and some calving and fawning areas.

Detailed information on big game is available from the Cooperative Wildlife-Phosphate Study area (IDFG) in adjoining Caribou County and the northern portion of Bear Lake County. Information on patterns of habitat selection, migration timing, and PATREC habitat potential could be transferred to the study area. Transfer of this information should be fairly straightforward.

Game Birds. Relatively few sage and sharp-tailed grouse leks are known. There is reason to believe that at these higher elevations, sage grouse do not use concentrated or traditional leks. Lek use appears to change each year and be less than in other areas; consequently, historic lek data may not be very useful at the elevations found in southeastern Idaho. Resolution of mapping for forest grouse is low, although habitat selection information may be used to assess impacts. Waterfowl data in and near Bear Lake Refuge is good, but entirely lacking on other sensitive and productive areas in the Bear River Valley. Little harvest data is available for these species, partly because of the small number of IDFG personnel in the area.

Endangered Species. Little data is available on suitable habitat for bald eagles and peregrine falcons in Bear Lake County, although it is available in Caribou County. Habitat suitable for probable further expansion of whooping crane migratory or breeding range has not been identified.

Furbearers. Data on furbearers other than beaver is either lacking or at a low level of resolution. Maps are limited to mapping of general vegetation types. Detailed information is available on beaver colonies and habitat, and on trapping harvest of all furbearers. Better data would be valuable for river otter and bobcat, which have been considered for threatened status, as well as lynx and marten, which are considered "sensitive" species by several agencies.

Game Fish. Data are reasonably complete, especially for Bear Lake and major streams. Additional data are desirable for small, high-elevation

streams. Livestock-fish interactions are not well documented, except in drainages where the Bonneville cutthroat has been studied.

Raptors. Raptor surveys are reasonably complete for common or visible species and for endangered and sensitive species such as the bald eagle, peregrine falcon, and prairie falcon. Nest inventories are not available for any other species, although habitat selection information is available for most. Information on owls and less common raptors is generally lacking. Information on very common species of lesser interest is also largely lacking.

Riparian/Aquatic Habitats. Inventories of wetlands and riparian habitats are reasonably complete. Meadow habitat adjacent to smaller waterways appear to be important to sage grouse and other species, but has not been inventoried. The effects of livestock grazing on riparian and aquatic habitats have been documented on only a few streams in the area.

Small Game Mammals. There is essentially no data on small game mammals. Data on cottontails is county-wide, which limits its usefulness for site-specific planning.

Nongame Mammals. Information on nongame mammals is limited to distribution and habitat. Some information on densities is available from Caribou County.

Nongame Birds. Information on nongame birds is limited in most cases to distribution and habitat. Documentation is good on the Bear Lake Refuge. Some "sensitive" species have been documented in reasonable detail. With the exception of USFS planning documents, there has been no use of nongame birds as ecological and management indicator species.

Nongame Fish. Available data is largely limited to occurrence and distribution within Bear Lake. The Bear Lake sculpin, an endemic species, is poorly studied.

Reptiles and Amphibians. Several species are believed to be potentially threatened but available information is limited to a single habitat matrix. No data appears to be specific to the study area.

Land Use Planning/Conflicts. Planning information on federal land is reasonably complete. Planning information at local levels may not be adequate. The effects of increased road access and off-road travel have not been assessed. The effects of housing and recreational developments on private lands have not been given adequate consideration.

General Information Gaps. Some data is currently available for most species and is relatively complete for high-priority species, particularly big game. The resolution of current data is, however, too gross to be of value for site-specific assessment. Therefore, with the current information level, planning efforts could only be conducted on a regional level.

The nature of oil and gas development impacts on wildlife resources will be variable, complex, and in some cases unknown. Direct effects, involving the loss of habitat potential, are site-specific and can be documented. Existing PATREC models could permit assessment of habitat for three big game species and could be expanded to other species of interest. The effects of increased human activity, both industrial and recreational, and the ability of wildlife to adjust to them are unknown.

SUMMARY EVALUATION OF DATA GAPS

Information gaps are summarized in the form of subjective ratings in Tables 3-4, 3-5, and 3-6. The subjective ratings are applied to seven information types for each species group. Three subjective ratings were used: minor, moderate, and major. A "minor" rating indicates that relatively complete information is available, and that it could be applied with only minor difficulties. The "moderate" rating means that relatively little information is available, information is lacking for one or more species in the group, or that the information may not be in a readily useable form. The "major" rating indicates that very little information is available, and/or the information would probably be difficult to apply. The tables also note where no information was encountered, or where a particular information type is not relevant to a species group.

Two types of modifiers for the subjective ratings are used in the tables. When a species, species group, or habitat element (e.g. antelope, waterfowl or lek) appears in parentheses the rating does not apply to the modifier, and indicates a greater information gap than shown in the table. Similarly, the "other than" modifier also excludes a particular species, but indicates lesser information gaps for that species. The other modifier type indicates potential problem areas that may limit applicability of data and result in a greater information gap. "Resolution" indicates that information covers large geographic areas, and may not be applicable to site-specific problems. "Subjective" means that information is qualitative and subject to varying interpretation. "Adjacent" indicates that detailed data are available from nearby areas, but may not be completely applicable to the study area.

The information gaps were rated for seven types of information commonly used for wildlife management. Information on critical areas includes identification of areas that are vital to a species group, such as winter range, nest sites, leks, and calving grounds. Habitat quality information pertains to the ability of habitat to support animals, based on food production, water availability, cover, and disturbance. Habitat quantity data are a real indicators of suitable habitat. Data on reproduction include reproductive output, numbers of breeding animals, and breeding requirements.

Population information includes total population numbers, population dynamics, and hunting statistics. Distribution data indicates where animals are found. Movements and migration information relates to routes used by migrating animals, migration timing, and factors triggering migration.

TABLE 3-4. INFORMATION GAPS, UTAH¹

	Critical Areas	Habitat Quality	Habitat Quantity	Reproduction	Population	Distribution	Movements and Migration
Big Game	Minor (resolution, fawning/calving areas)	Minor (resolution)	Minor (resolution)	Minor (antelope)	Minor (antelope)	Minor (antelope)	Minor (resolution)
Game Birds	Moderate (leks, waterfowl)	Minor	Minor	Minor	Moderate (other than sage grouse)	Moderate (other than sage grouse)	Moderate
T&E Species	Moderate (ferret)	Major	Moderate (ferret)	Major	Moderate (ferret)	Moderate (ferret)	Moderate
Furbearers	Minor	Minor (subjective)	Minor (resolution)	Moderate	Moderate (subjective)	Moderate (other than beaver)	*2
Raptors	Moderate (uncommon species)	Moderate	Major	Moderate	Moderate (uncommon species)	Moderate (uncommon species)	Major
Game Fish	Minor	Minor	Minor	Minor	Minor	Minor	NA ³
Small Game Mammals	*	*	*	*	Moderate	Moderate	NA
Nongame Mammals	*	*	*	*	*	Major	*
Nongame Birds	*	Major	*	*	*	Major	Moderate
Reptiles & Amphibians	*	*	*	*	*	Major	NA
Nongame Fish	*	Minor	Minor	*	Minor	Minor	NA

¹The terms used in the table are explained in the text.

²"*" indicates that no information was encountered on the subject.

³"NA" indicates "not applicable," meaning that the species group is generally nonmigratory and/or sedentary.

TABLE 3-5. INFORMATION GAPS, WYOMING¹

	Critical Areas	Habitat Quality	Habitat Quantity	Reproduction	Population	Distribution	Movements and Migration
Big Game	Minor (resolution)	Major	Moderate (resolution)	Moderate (resolution)	Moderate (resolution)	Minor (resolution)	Minor (resolution)
Game Birds	Moderate (other than sage grouse)	Major	Moderate (resolution)	Moderate (resolution)	Moderate (resolution)	Minor (other than sage grouse)	Minor
T&E Species	Minor (other than bald eagle)	Moderate (other than bald eagle)	Minor (other than bald eagle)	*2	Minor (other than bald eagle)	Minor (other than bald eagle)	Minor (other than bald eagle)
Furbearers	Moderate (other than beaver)	Major	Moderate (other than beaver)	*	*	Moderate (other than beaver)	NA ³
Raptors	Moderate (uncommon species)	*	*	Major	Moderate (uncommon species)	Moderate (uncommon species)	*
Game Fish	Minor	Minor	Minor	*	Minor	Minor	*
Small Game Mammals	*	*	*	*	Moderate (resolution)	Major	NA
Nongame Mammals	Moderate	Major	*	*	Major	Major	NA
Nongame Birds	*	Major	Major	*	Major	Major	*
Reptiles & Amphibians	*	*	*	*	Moderate	Moderate	*
Nongame Fish	*	Moderate	Minor	*	Moderate	Minor	NA

¹The terms used in the table are explained in the text.

²"*" indicates that no information was encountered on the subject.

³"NA" indicates "not applicable," meaning that the species group is generally nonmigratory and/or sedentary.

TABLE 3-6. INFORMATION GAPS, IDAHO¹

	Critical Areas	Habitat Quality	Habitat Quantity	Reproduction	Population	Distribution	Movements and Migration
Big Game	Minor (resolution)	Minor	Minor	Minor (adjacent)	Minor	Minor	Minor (resolution)
Game Birds	Minor	Minor	Minor	Minor	Minor	Minor	Minor
T&E Species	Minor	Moderate	Moderate	Moderate	Minor	Moderate	Minor
Furbearers	Minor	Major (other than beaver)	Minor (resolution)	Major	Moderate	Moderate (other than beaver)	*2
Raptors	Moderate (uncommon species)	Minor	Major	Moderate (uncommon species)	Moderate (uncommon species)	Moderate (uncommon species)	Moderate
Game Fish	Minor	Minor	Minor	Minor	Minor	Minor	NA ³
Small Game Mammals	*	Moderate	*	*	Moderate	Moderate	NA
Nongame Mammals	*	*	*	*	Moderate (adjacent)	Moderate	*
Nongame Birds	Major	Moderate	*	*	*	Major	Moderate
Reptiles & Amphibians	*	*	*	*	*	Major	NA
Nongame Fish	Major	*	*	*	*	Moderate	NA

¹The terms used in the table are explained in the text.

²"*" indicates that no information was encountered on the subject.

³"NA" indicates "not applicable," meaning that the species group is generally nonmigratory and/or sedentary.

RECOMMENDATIONS

The following section describes information gaps which are significant and should be dealt with in Phase II of the Cooperative Wildlife Program. Information gaps which are less significant are also identified. Detailed recommendations for work on these items appear in the final chapter of this report.

Utah

High-Priority Research. The most significant problem associated with big game information is the large scale nature of most data. The mapping system employed by UDWR alleviates this problem to a degree, but requires refinement for optimal value in planning. To illustrate, deer maps currently allow a planner to see that an entire section of land is within deer winter range. The maps do not allow identification of the least sensitive areas (i.e. north aspects with deep snow, dense coniferous stands) which would be preferable for siting of facilities over more sensitive locations (south aspect slopes with key winter browse species). The resolution of the UDWR mapping system should be improved to allow such use. The PATREC system and preference (availability vs. use) method employed by the Idaho Department of Fish and Game may be useful in this process. An effort should be made to identify important summer range on a mapping system, particularly fawning or calving areas. A high level of resolution could be incorporated into the maps resulting from this work. A research program to determine the numbers, composition, and management strategies for the antelope in the Crawford Mountains should also be considered.

As part of a more comprehensive habitat mapping project, potential sage grouse habitat might be surveyed to locate any additional leks that have not been found and to verify the use and location of those which are known. Surrounding critical habitat, such as meadows, might also be identified. Waterfowl work could also concentrate on a mapping effort to identify sensitive and productive habitat. This project may be efficiently done in combination with an inventory of wetlands and other riparian/aquatic habitats.

Endangered species work probably should focus on the black-footed ferret and the Bonneville cutthroat trout. As part of an overall habitat mapping program, all possible black-footed ferret sightings in the area could be compiled on a map suitable for use in the study area, and prairie dog towns could be mapped from aerial photos. Field verification should probably be done as the need arises for specific projects. The locations of pure strains of Bonneville cutthroat trout could be mapped.

Two projects might be initiated for raptor management. A visit could be made to all known nests on UDWR and BLM maps to check for occupancy and assign management priority. Data on the aspect, phenology, and sensitive areas (such as the area below the nest, perch sites, etc.) could either be included on the

maps or as part of a data base to allow better use of nest site maps for planning. The second project might be a compilation of nest site information from environmental statements, field notes, and similar sources for species such as Swainson's hawk, goshawk, osprey, and burrowing owls. Site-specific surveys for great gray owls may be warranted if oil and gas exploration is anticipated in high elevation montane meadow areas.

Additional information on riparian habitats, particularly wetlands, could be collected and mapped, as mentioned above. This project would serve the purpose of identifying environmentally sensitive areas, identifying productive areas for waterfowl and some upland game birds (sage grouse and ring-necked pheasant). The project probably should at least include the Bear River bottomlands, but the value of the work for planning purposes would be increased if wetlands were mapped in the vicinity of sage grouse leks and deer fawning areas.

Low-Priority Research Needs. Information on upland game birds other than sage grouse is not of critical importance. Site-specific research may be necessary in a few cases. For example, the most significant cause of pheasant mortality elsewhere in Utah has been found to be mowing of hayfields before the hatch. If this was found to be the case in the study area, the loss of pheasant habitat could be mitigated by cooperating with the owner of the field to delay mowing until after the hatch.

The possibility of using nongame birds and mammals as ecological indicators could be explored. The major value of such work would be to facilitate more cost-effective impact assessment and monitoring of large scale operations. Bird species diversity and similar indices can be collected more quickly than most other types of wildlife data, which would minimize delays for environmental studies.

Whooping crane range expansions into Utah are not likely in the near future, although some stragglers have been noted along the Bear River in Idaho not far from Utah. Further study of this species would be beneficial, but the need is not immediate, since wetlands are protected by current policy and will be evaluated as part of a larger habitat survey.

Additional research on furbearers is not necessary. Beaver data is reasonably complete, and impacts on beaver can be avoided for the most part by avoiding sensitive riparian areas. Projects requiring large amounts of water may require further beaver studies. Other furbearers have low populations, are wide-ranging, and are generally difficult to study and manage. Efforts specifically directed toward these species are not likely to be cost-effective.

Research on the more common species of raptors is not critical to management efforts. These species are relatively flexible in their requirements and relatively tolerant of human activities. Efforts would be better directed toward more sensitive species.

Additional research on small game mammals, nongame mammals, birds and fish, and reptiles and amphibians is not necessary. These species are of relatively little interest to the public and wildlife management agencies. Oil and gas development is also unlikely to have a significant impact on these animals.

Wyoming

High-Priority Research. There are three categories of information gaps or inadequacies that apply to all wildlife within the study area. These are 1) inadequate habitat information; 2) large-scale resolution of existing distribution and population data; and 3) uncertainty regarding the effects of development activities, such as oil and gas, on wildlife. Time and budget constraints limit the extent to which these data gaps can be filled and recommendations must center on high priority species and species groups.

In Wyoming, high-priority groups include big game, game birds, game fish and threatened, endangered or sensitive species. Lower-priority categories include furbearers, small game mammals, raptors, nongame mammals, birds, and fish, and herpetofauna. However, if properly planned, research focusing on high-priority species can supplement information on these low priority categories.

Big game habitat information is incomplete. An area-wide habitat inventory and evaluation is needed, before site-specific disturbances and the cumulative effects of development can be understood and predicted. Coordination of habitat evaluations with ongoing industry, state and federal projects will insure data compatibility and interagency use of combined information. Primary efforts should center on big game winter range, riparian areas, and wetlands. These areas overlap important habitats for several of the high-priority species groups.

The ultimate concern of wildlife/human interaction evaluations is maintenance of acceptable wildlife reproduction and population levels. The level of resolution of data for big game in the study area does not permit adequate analysis of reproductive success and population parameters in relation to habitat quality or to the effects, adverse or beneficial, of resource developments. For example, data summarized for an entire Data Analysis Unit cannot be used to explore the effects of human disturbance on big game movements, home range, habitat use, and behavioral or physiological responses of big game species. Tagging and collaring studies, primarily on mule deer, can be used to infer gross movement patterns but these data do not provide insights to dynamics of human/big game interactions. Research is recommended to refine big game population, reproduction, movement, habitat use, and behavioral information within the study area. Studies need to be designed so that human influences and other environmental factors affecting these parameters are examined.

Similar information is needed for game birds. Sage grouse and Canada geese are best known of all game birds in the study area. However, sage

grouse leks have probably not been thoroughly documented in the study area and wintering areas and important brood-rearing habitats are largely unknown. Canada goose nesting areas are well documented for some areas but breeding area inventories for other waterfowl have only recently been initiated. The study area-wide habitat inventory and evaluation recommended above would necessarily include or supplement existing inventories of wetlands and riparian areas, both of which are potentially valuable to sage grouse and waterfowl. Recommendations for Phase II study therefore include compilation of all known sage grouse leks and wintering areas as well as known waterfowl breeding areas followed by a study area-wide survey for additional critical game bird areas coordinated with habitat evaluation and inventory studies.

Aquatic systems and game fish data are available for many waters in the study area. Agency files should be examined to determine the extent of data available for specific streams and standing waters of interest. Streams with documented populations of Bear River and Colorado River cutthroat trout populations should be re-evaluated for populations, genetic purity and habitat quality trends. Additional streams not included in past fisheries surveys need to be identified and evaluated for resident fish populations and sensitivity to current or future development.

Finally, high priority should be given to further research on black-footed ferret and bald eagle use or potential occurrence in the study area. Additional documentation of white-tailed prairie dog towns could presumably be coordinated with area-wide habitat inventories. Similar coordination is possible for bald eagle wintering areas, especially for the Rock Creek roost north of US 30. In all cases, habitat inventories and population surveys for these species should be coordinated with industry, state and federal agencies that have conducted previous surveys and studies in the area.

Low-Priority Research Needs. Generally, the study area has not been surveyed for either furbearer populations or raptor use. Information on both of these wildlife categories could be documented during the course of an area-wide habitat study. Beaver dam locations could be compiled for follow-up examination. The same is true for documented raptor nest site locations. Use of beavers for stream and wetlands rehabilitation has been recommended by BLM personnel and could be implemented if willow and aspen treatment or regeneration projects are initiated. If a thorough area-wide survey of raptor nest sites and beaver dam locations is impossible, priority might be given to intensive searches in areas of present developments. Monitoring studies would be valuable to determine the nature of impacts, if any, on these species and respective habitat quality changes.

Small game mammal, nongame birds and mammals, nongame fish and herpetofauna can serve as indicator species for local environmental quality. This assertion has been made before but should be given careful consideration for use with unique or limited habitats in the study area. First consideration should be given to nongame wildlife occurrence in the vicinity of current development with control areas far removed from development but which are otherwise comparable. Further nongame/habitat associations can be developed

in areas slated for development. Depending on intra-habitat variations of small game and nongame mammals and nongame bird occurrence, the entire study area or large portions thereof could be mapped for potential populations of these wildlife categories once habitat information is known. Mapped information of this nature, if adequately verified, could be valuable for planning future industrial activities. In any case, valid low-priority game and nongame wildlife observations, whether part of a formal study or incidental to other research activities, should be documented and submitted for incorporation in existing wildlife data bases.

In summary, an overriding need for Phase II research is for habitat related surveys. These studies may be coordinated with other existing and planned surveys. Identification and evaluation of priority species' critical and seasonally used areas can then serve as a template upon which site-specific evaluations of developments can be conducted. Information available only for large scale areas needs to be augmented by site-specific inventories, population, reproductive, and behavioral data which can be translated to fine-resolution maps, overlays or data bases for use in future planning efforts.

Idaho

High-Priority Research. High priority should be given to game species on public lands. Interpretation of current knowledge suggests that these species will carry the weight of development, expressed as increased mortality, particularly from legal and illegal harvest. Increased enforcement may be a solution to this problem. Its effectiveness could be evaluated as development occurs. Further research is needed to establish magnitude of the impacts on big game populations, and to evaluate potential solutions.

Potentially sensitive fisheries are also a high priority concern. Increased harvest could have an impact on some populations. Bonneville cut-throat trout populations might be further studied, especially in the small upper tributaries. Critical spawning areas for adfluvial trout should be identified. Site-specific electrofishing surveys of high-elevation streams could be made to obtain pre-impact baseline data.

Further inventories of riparian and wetland habitats are needed. These areas are highly productive wildlife habitat and important to many sensitive, threatened, or endangered species. Wetlands are also highly productive nesting habitat for waterfowl and nongame birds. At the minimum, surveys of Bear River bottomlands should be made.

Evaluation of the effects of development on critical big game use areas is necessary. These include wintering areas, elk calving areas, and migration corridors. Ecological arguments suggest that natural selection has led to the development of critical seasonal-use areas and movement-activity patterns, which maximize survival and reproductive success for a species. Disruption of these critical areas or additional stress in response to resource development could have negative impacts on populations, but current research is inadequate to verify this hypotheses. These effects may be subtle, cumulative, and

difficult to measure. Additional research is needed to properly understand the impacts on big game.

Low-Priority Research Needs. Low-priority research includes game bird, raptor, nongame, and furbearer research, and investigations into aspen regeneration techniques. Although there is currently very limited information available for these topics, obtaining adequate information for intensive management would be difficult and time consuming. Gamebirds and raptors will probably adapt to development. In addition, management of furbearers is made more difficult by wide-ranging movements and low densities.

Consideration should be given to use of selected nongame birds as management indicator species. This could facilitate rapid, more cost-effective impact assessment and monitoring of large-scale operations. Species diversity and presence of particular species can be determined rapidly, and used to assess ecological "health" of an area. Rapid assessment may minimize delays for environmental studies.

Further information on aspen succession, its effect on wildlife species, and possibilities for treatment and regeneration would be useful. Aspen succession is an important problem in the study area. Aspen treatment is a valuable tool for off-site mitigation of impacts, and is currently being studied by the USFS Intermountain Forest and Range Experimental Station and the Cooperative Wildlife-Phosphate Study. The findings of these studies may be applicable to the Overthrust Belt, and additional research is not warranted at this time.

Changing land uses should be considered in assessing wildlife resources. Increased human populations are expected to lead to increased recreational use and increased harvest. Off-road travel will have important effects on wildlife populations. Increased human populations from many sources could reduce water quality of Bear Lake, and consequently affect numerous species of game fishes, including four endemic species. Changes in land use should be monitored and mapped.

In summary, significant information gaps exist in the Idaho study area. They exist in a spectrum of priorities that suggests that big game and game-fish species on public lands are the primary concerns. An opportunity for sophisticated, manipulative big game research exists on the Cooperative Wildlife-Phosphate study area on the northern edge of the study area. This area is unique in that five years of baseline data has already been gathered. The ability to investigate wildlife impact problems more quickly and efficiently than by establishment of a new study area elsewhere would be provided. It should also be recognized that this research project has completed several studies that could be applicable to the high-priority information gaps present throughout the three-state study area. Research needs would also be facilitated by an existing baseline data base on nongame species.

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PUBLIC INVOLVEMENT AND PCC REVIEW

Phase I of the Cooperative Wildlife Program Wildlife Study provided for a public workshop and three meetings with representatives of the Project Coordinating Committee (PCC). The public workshop was intended to accomplish several purposes. One purpose was to describe the Cooperative Wildlife Study to interested members of the public and organized interest groups. The primary purpose was to provide an opportunity for people to comment on the impacts of oil and gas development on wildlife in the Overthrust Belt and to offer suggestions as to the scope and conduct of the literature review. The workshop was held on September 20, 1982, at the Sheraton Motor Lodge in Evanston, Wyoming. It began with a statement of the purpose of the Cooperative Wildlife Program and the Wildlife Study by the Contract Administrator, Mr. Patrick O'Brien of Chevron U.S.A. (The Wildlife Study is one of three elements of the overall Cooperative Wildlife Program.) The consultant then described the project team, the scope of work to be conducted during Phase I, and the expected products and applications. These introductory statements were followed, first, by general questions about the Wildlife Study, and thereafter by more specific comments and questions regarding impacts and the scope of the study. The workshop lasted approximately three hours. A summary of comments made at the workshop is included as Appendix A to this report.

The first meeting with PCC representatives was held the same day as the public workshop. At this meeting, members of the consultant team from LSA and the University of Wyoming introduced the plan of work for Phase I and responded to comments offered by the PCC representatives.

The second meeting with the PCC representatives was held on August 12, 1983, also at the Sheraton Motor Lodge in Evanston. This meeting comprised three sections. The first section was arranged to present the results of the literature review and to promote discussion among PCC representatives and study participants. The second section was used to review the status and products of the Environmental Awareness Program, another element of the overall Wildlife Program, and was directed toward agency and industry personnel. The third section of the second meeting was intended to initiate discussions regarding the focus and content of studies to be conducted in Phase II.

The third meeting with the PCC was held over two days on September 8-9, 1983, in Laramie at the University of Wyoming. The third meeting had three purposes. The first of these was to conduct a technical review of the Phase I report. Reviewers received the report at the August 12th meeting and were encouraged to examine it critically. This critical examination produced numerous comments and questions about the content and organization of the report and provided the basis for the technical review at this meeting. The second purpose of the meeting was to examine and prioritize the data gaps identified in the Phase I report. Data gaps identified were grouped as gaps in basic resource data, gaps in understanding of impacts, and gaps in the understanding of mitigation success. The third purpose of the meeting was to prioritize the objectives for work to be conducted in Phase II.

MITIGATION OF WILDLIFE IMPACTS

INTRODUCTION

The first oil and gas discovery in the Overthrust Belt, in 1975, brought with it the promise of an important new energy source and economic prosperity for many Overthrust Belt communities. It also brought the challenge of conducting development in a manner compatible with the environment and nature.

For several years, the debate regarding the effects of development upon area wildlife continued. The Cooperative Wildlife Program, particularly the study portion, is an effort by industry, public wildlife management agencies, and private wildlife organizations to go beyond the emotionalism of the issues and develop a strong scientific base from which rational decisions about how best to protect wildlife can be made.

The following discussion introduces a comprehensive table (Table 5-1) which summarizes the measures proposed or taken to mitigate the effects of several component activities of oil and gas and other development. These activities have been discussed randomly and sometimes emotionally during the recent past. The table includes no judgments as to whether the listed impacts are real or whether the potential mitigation measures are effective. It simply presents what has been found in the literature and/or been stated by industry or various groups concerned about wildlife in the Overthrust Belt. Because it is a key issue under current economic conditions, the table has been developed to contain information on the costs of mitigation.

No recommendations of any type should be construed from Table 5-1. The table simply provides a base for the Phase II research. As Phase II continues, this table will be revised to reflect the results of new or more accurate data.

DEFINITIONS

It is useful to begin the discussion by defining mitigation -- as a means of avoiding loss, restoring, or minimizing loss of wildlife benefits. A more practical description is provided below because it will facilitate cooperation if participants in the Overthrust Belt interpret the subject in a similar manner (Rappoport 1979). Wildlife agencies often perceive mitigation as accepting a changed environment, which may well include at least some unavoidable losses of wildlife and decreased recreational opportunities. This often occurs because the mitigative attempts following disturbance do not provide new opportunities for management. Indeed, some activities associated with oil and gas development may not be mitigable in the short-run, or at least until an oil or gas field is abandoned. Residual impacts may persist despite mitigative efforts in the cases of blow-outs, spills of mud-pit chemicals, pipeline leaks, or fires.

However, many forms of mitigation can definitely increase wildlife management opportunities, which will be described below. Jahn (1979) defined mitigation on the basis of various procedural components:

1. avoidance - avoiding adverse impacts by not taking a certain action or part of an action;
2. impact minimization - minimizing impacts by limiting the degree or magnitude of damage in unavoidable situations;
3. reclamation - rectifying impacts by repairing, rehabilitating, or restoring the affected environment;
4. replacement - offsetting impacts by providing substitute resources of habitats acceptable to species other than those originally present;
5. habitat improvement - offsetting impacts by manipulating environments to increase carrying capacities, usually off-site, for the affected species.

Mitigation by Avoidance and Impact Minimization

Mitigation is usually easiest and cheapest to achieve by using avoidance or impact minimization procedures. Benefits to wildlife resources will be greater if available funds are used more for mitigation by avoidance (Thompson 1979) and habitat improvement (i.e. solving problems) than for traditional inventory and impact analyses (i.e. defining an already presumed problem).

Impact minimization acknowledges that some losses will occur simply because certain environmental changes necessarily occur due to roads, stream crossings, drill pads, etc. The charts describe steps that will serve to minimize losses of wildlife and their habitat.

Mitigation by Replacement

This form of mitigation also includes acceptance of a changed environment, including a new array of plant and animal communities. For oil and gas development, replacement would involve substitutions of wildlife habitat lost through road construction and wellsite development. In general, replacement offers a chance for enhancing wildlife management and recreational opportunities in disturbed areas, but it was not emphasized in the literature and consequently is scarcely mentioned in Table 5-1.

Reclamation

Reclamation is an oft-used procedure that in the past frequently aimed at re-establishing vegetation on denuded sites without defining which vegetation would be most useful in an ecological context. Judicious reclamation can provide new wildlife management opportunities. Reclamation, as it is currently practiced, could yield a plant community or mosaic of plant communities

which meet wildlife habitat requirements, including structural and species diversity as well as proper interspersions of food, cover, and water. Some of the current reclamation practices used in Idaho, Wyoming, and Utah are discussed in Appendix E.

Habitat Improvement as Mitigation

Although it has not received the same attention as other measures (Thompson 1979), habitat improvement is a mitigative process which can produce benefits to wildlife over a large enough area to perhaps completely off-set losses incurred elsewhere. Traditional ecological impact analyses all too often focus upon site specific issues without considering the overall response of a wildlife population. Predictions of mortality are inadequate for estimating effects as long as the habitat continues to provide the potential for a wildlife population to respond to increased mortality, just as hunted species are capable of responding to hunting mortality. Natural resource managers can capitalize upon the response capabilities of wildlife populations by conducting habitat improvements. Habitat improvement can off-set disturbances to habitats as well as those that cause wildlife displacements.

DESCRIPTION OF TABLE 5-1

Potential mitigative recommendations presented in the following table were often results of presumed, rather than clearly documented impacts. Thus, mitigation alternatives, for example, were often based upon conservative viewpoints characteristics of natural resource management agencies. All too often, the recent nature of the suggestions has not allowed for an adequate evaluation of the efficacy of the mitigation procedures. In other cases, mitigation suggestions were applied but no monitoring occurred to determine if benefits accrued to wildlife populations. For example, it has been shown in wildlife law-enforcement files that increased illegal hunting results from increased human populations in newly developed areas. However, no quantitative studies are available which evaluate subsequent wildlife population changes. The problems involved with inadequate evaluations of wildlife benefits following application of mitigative procedures were discussed above.

Construction of Table 5-1 drew heavily from potential mitigative practices gleaned from literature not necessarily specific to oil and gas disturbances. This literature documented effects of various habitat changes and human disturbances which are applicable to the Bear River Divide situation. Some of the literature we examined were agency reviews of oil and gas impacts which did not list their literature sources.

Table 5-1 is organized by headings related to activities associated with major phases of oil and gas developments. These are: 1) seismographic activities, 2) exploratory drilling, 3) well site access, 4) well site and field development facilities, and 5) well site and road abandonment. For each major phase in development, information pertinent to industry activities, effects on wildlife, and mitigation alternatives is provided in eight columns:

- Column 1: Component activities associated with a particular development phase.
- Column 2: Subjects warranting special consideration given their relationship to or the effects of the component activity. Most often, these special considerations are discrete wildlife groups or fish and wildlife habitats.
- Column 3: Potential effects of the component activities on the fish, wildlife and/or habitats listed in Column 2.
- Column 4: Sources of documentation of effects due to activities listed in Column 1. Most often, documentation was derived from sources not associated with oil and gas developments.
- Column 5: Mitigation alternatives are listed as potential methods for potential effects on wildlife, fish, and/or habitats. The cost of each mitigation alternative is omitted. Costs need to be determined in the planning stage of each project and could be greatly facilitated if it were done at the company level with input from staff personnel who can give accurate estimates of each alternative.
- Column 6: Situations and/or locations where the mitigative alternatives listed in Column 5 have been recommended or applied.
- Column 7: Sources documenting these recommended or applied mitigative alternatives.
- Column 8: Comments explaining special circumstances or details relevant to understanding how the information on potential effects of component activities on fish and wildlife, its documentation, the mitigative alternatives, and/or the documentation of these alternatives might be applied to oil and gas developments.

**TABLE 5-1. MEASURES CURRENTLY USED OR PROPOSED TO
MITIGATE THE IMPACTS OF DEVELOPMENT ON WILDLIFE**

SEISMOGRAPHIC ACTIVITY

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
	Bighorn sheep	Displacement from preferred areas, resulting in excess energy expenditure during critical winter periods	MacArthur et al. 1982	Maintain flight corridors away from important areas and maintain at least 250 m altitude. Maintain flight altitudes below upper limit of timberline	Oil and gas development, Alberta	Stubbs and Markham 1979	The study found no displacement with helicopters or fixed-wing aircraft at distances greater than 400m from sheep. However, during 5 direct overflights by a Bell-206 or Hughes-500 helicopter at 90-250m above ground, sheep heart rates were 2 to 3.5 times normal and sheep ran vigorously for 22-65 seconds. Unknown whether this is detrimental.
	Dall sheep moose	"	Lenarz 1974	Cost: Avoid important sheep wintering areas; prevent harassment Cost:	Oil and gas development, Alberta, Canadian Arctic	Stubbs and Markham 1979 Lenarz 1974	In studies of reactions to an FH-100 helicopter, sheep were found to be much more reactive than moose, which often remained motionless. It may be possible that the quality of security cover plays a large role in the type of response, but research is needed.
	Deer, Elk	"	Unknown	Develop flight corridors to avoid important areas Cost:	Oil and gas development, Wyoming	USDI, Bureau of Land Management 1979	Common sense suggests avoidance of calving/fawning areas which may be mapped by wildlife agencies; also crucial wintering areas probably ought to be avoided; however, no studies documented mortality as a result of additional expenditures of energy.
Survey and clean-up crews	Big game	Displacement from preferred habitat	Ward et al. 1976; Ward 1978	Concentrate activities as much as possible Cost:	Oil and gas development, Alberta	Beak Consultants Ltd. 1979	Potential disturbances caused by humans out of vehicles are highest when vegetation does not limit visibility.
Thumper trucks, Vibraselsers	Burrowing owls, prairie dog colonies	Cave-ins of prairie dog burrows	Unknown	Plan ahead with survey crews to avoid problems with resident species Cost:	Oil and gas development, Alberta	PRISM 1982	Prairie dog colonies may be potentially used by the endangered black-footed ferret. Such areas, including those attractive for burrowing owls are those which are isolated from human disturbance (Zarn 1974). Prior planning can eliminate conflicts between industry and key habitats (PRISM 1982).

SEISMOGRAPHIC ACTIVITY

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Camps	mountain meadows	displacement of big game from important feeding areas	Johnson and Lockman 1980; Rost and Bailey 1979; Ward et al. 1972	Locate camps away from important meadows (100 m or more) Cost: Educate personnel about wildlife harassment or limit concentrated use of disturbing activities Cost:	Oil and gas development, Alberta	Stubbs and Markham 1979	Meadows along a major, improved, heavily-used road are likely less important to wildlife and interactions are more likely in areas with lower human use.
Camp personnel	general wildlife	Indiscriminant Recreational use of all-terrain vehicles, and firearms by camp personnel may cause displacement or wildlife mortality	Smith and Bloomfield 1980		Same as above	Stubbs and Markham 1979	
Explosions surface shot heli-drilling	crucial big game winter ranges	Range abandonment, additional mortality hypothesized, due to lack of reserves of body		Avoid disturbing activity within 2 miles of winter range from Dec 1 to May 1 Cost:	Oil and gas development, Alberta and Wyoming	Stubbs and Markham 1979; USDI, BLM 1979	No population changes have been observed; most authorities assume additional movements during critical winter periods produce stress which could affect population dynamics, but further research is needed. Local game officials will relax restrictions in areas where game are not concentrated due to a light winter.
	calving-fawning areas	Displacement, potential for range abandonment	Knight 1980	Avoid disturbing activity on crucial big game fawning, lambing, or calving areas from May 1 to June 30 Cost:	Oil and gas development, Michigan, Wyoming and Alberta	Knight 1980; Schlegel 1978; Markham 1979	Female big game animals with young appear more reactive than other groups; the potential for mortality to young animals appears high because of the vulnerability to predation, accidents, or diseases if movements are frequent and unusual, although, more research is needed. The potential effects of seismic explosions on big game habitat use & subsequent population effects are unknown. Most studies have been preliminary in nature (Hoskins 1981, Isle 1982, Olson 1981).
	Red-tailed hawks	Nest abandonment	Allredge and Shickler (unpub), Boeker and Ray 1971; Camenzind 1969	Gain knowledge of nest-sites, attempt to avoid disturbance during nesting season Cost:	Oil shale development, Rio Blanco Co., Colorado	Allredge and Shickler (unpub); Olendorff et al. 1980	Four of 13 red-tailed hawk pairs abandoned nests following explosions; it was unknown whether or not they returned the next year. Owls nest as early as February, and for other species, the nesting season may last from March or April through June or July. Avoiding rocky cliffs could be beneficial. Some raptors nest in dense aspen stands (Coopers hawk, Jones 1979) and riparian sites are often important (Dunkle 1977).
	Waterfowl nesting areas	Nest abandonment, especially sand-hill cranes, swans or geese	Barry and Spencer 1976	Restrict disturbing activities within 400m of important nesting habitat for spring Cost:	Oil and gas development, Alberta	Stubbs and Markham 1979	No quantified studies have been made which evaluated the potential effects of seismic explosions on waterfowl. Probably, the effects of humans are greater than the noise.
Helicopters	Moose	Displacement from preferred areas, resulting in excess energy expenditure during critical winter periods	Horejsi 1979	Attempt to minimize length of time spent along a seismic line via planning activities Cost:	Oil and gas development, Alberta	Horejsi 1979	Seismic lines are cut through the forest, and bulldozers and trucked vehicles are used in addition to a Bell 206 helicopter. Moose returned to areas along seismic trails soon after seismic crews left the areas.

SEISMOGRAPHIC ACTIVITY

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Thumper trucks, vibraseisers (cont'd)	open habitat	increase in off-road vehicle traffic, producing erosion, wildlife displacement, or possible poaching	Wilshire et al. 1978; Eckert et al. 1979; Baker and Laflen 1979	attempt to keep seismic trails from appearing as roads by disguising points where lines cross established roads: Cost:	Oil and gas development, Alberta	Stubbs and Markham 1979; Smith and Bloomfield 1980	One approach is to create short dog-legs as seismic lines cross roads, so that the lines appear to stop a short distance from the road. It may be possible, in some cases, to discourage off-road traffic by placing boulders or earth-banks at points where seismic lines cross roads.
	Big game winter range, calving areas	same as for seismic lines with explosions, described above	Unknown	Avoidance of critical winter range from 10/15 to 5/15. Calving areas from 5/15 to 6/30	Oil and gas development, Wyoming	USDI, Bureau of Land Management 1979	
Surface Drilling of Shot Holes	aquifers or surface water	release of contaminated water into ecosystems	Millis 1969 and 1972	cement from 20 ft. above to 20 ft. below aquifer Cost:	Oil and gas development, Wyoming	Same as above	Developing good water on big game winter range may encourage summer use by livestock and big game, reducing winter food availability. However, the potential for improving big game habitat exists, and experimentation may be warranted.
	coal-bearing formations	potential for spontaneous combustion, range fires	Unknown	cement to 20 ft. above and 20 ft. below the coal, with a 5 ft. plug 2 ft. below surface Cost:	Same as above	Same as above	

EXPLORATORY DRILLING

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Well Site Selection	General Wildlife Habitat	On site direct loss of habitat; displacement/ avoidance of resident wildlife population concentrations and over utilization off-site; decreased survival of young due to use of sub-optimal habitat; increase in human confrontations	USDI, Bureau of Land Management 1979	Confine disturbance to smallest area possible <u>Cost:</u>	Oil and gas development, Washington	Washington Dept. of Game 1980	Common sense dictates habitat losses and wildlife displacement will be minimized with minimal surface disturbance. However, no studies relate size and duration of disturbance to magnitude of wildlife response. In the Kemmerer Resource area pads will average 5 acres of surface disturbance (USDI, BLM 1979).
	Elk	None discerned, although displacement often hypothesized.	Knight 1980	ON SITE: Maintain steady work pace and maintain low noise levels <u>Cost:</u>	Oil and gas development, Alberta	Beak Consultants Ltd. 1979 Geist 1971	Studies of elk response to oil well drilling activities provide conflicting results. Neither Knight (1980) nor Beak Consultants (1979) demonstrated adverse reactions to drilling rigs by elk although the reasons for low responsiveness differ: Knight (1980) concluded elk were habituated to the activity while Beak Consultants (1979) believed rig placement and concealment key factors in avoiding elk and moose impacts. While Johnson and Lockman (1980) indicated elk displacement away from drilling activities they could not state conclusively whether this was due to the rig itself or to yearly variation in elk distribution: no control area was examined in the study design. Likewise, Hiatt and Baker (1981) had no control and very little pre-impact data with which to compare effects of an active rig on elk and mule deer distribution.
	Elk	Apparent displacement of elk away from drill rig	Johnson and Lockman 1980	Same as above	Same as above	Same as above	
	Elk and Mule deer	Inconclusive although some movement away from drill rig was observed	Hiatt and Baker 1981	Same as above	Same as above	Same as above	
	Elk and Moose	None; apparent habituation to presence of drill rig	Beak Consultants Ltd. 1979	Locate drill rig in forest, 700m from suitable winter habitat; locate rig crew camp and access road in forest rather than meadows; site rig above surrounding elk and moose winter habitat to reduce noise; no active harassment by drilling personnel <u>Cost:</u>	Same as above	Same as above	

EXPLORATORY DRILLING

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Well Site Selection	Furbearers	Loss of prey and supporting habitat Dispersal away from drill pad resulting in possible overcrowding and increased competition in adjacent areas	Brink 1978 Unknown	Confine disturbance to smallest area possible <u>Cost:</u> Limit surface occupancy to shortest duration possible because furbearers may return in 2-4 wks after drilling operations cease <u>Cost:</u> Avoidance of important goose and swan nesting/summering areas if rig is located nearby Habitat manipulation and improvements are specified, below <u>Cost:</u>	Oil and gas development, Washington Oil and gas development, Michigan	Washington Dept. of Game 1980 Bennington et al. 1982	Bobcat, black bear and elk use within 1/4 mile of a drilling rig decreased but returned to "normal" levels within 2-4 wks. after drill site abandonment. The authors conclude that one well per 2 sq. mi. did not adversely affect the three species. Although avoidance of the drill pad by swans and geese was documented, the authors could not state whether drilling or helicopters arriving at the pad were the cause. They suggest use of fixed wing aircraft to reduce disturbance. However, creation of runways increases surface disturbance and may offset benefits of fixed wing aircraft.
	Swans and Geese	Avoidance of drill rig site during molting period	Barry and Spencer 1976		Oil and gas development, Mackenzie Delta NWT	Barry and Spencer 1976	
	General Wildlife Habitat	On site loss of habitat; displacement/avoidance of resident wildlife population concentrations and overutilization off-site; decreased survival of young use of sub-optimal habitat; increased human confrontations and conflicts with agriculture if displacement to croplands	See ON SITE loss of habitat above		Oil and gas developments, Alberta	PRISM 1982	If the oil and gas industry is to proceed in exploratory drilling, vegetation will be lost and wildlife habitat will be disturbed on site. The effects of disturbance may extend beyond the drill pad boundary (see above) and cause wildlife to move into adjacent areas thereby increasing the potential for sub-optimal habitat use, conflicts with agricultural land use, and human confrontations. Below are listed off-site potential mitigative procedures for redirecting and augmenting wildlife habitat use.
	Mule Deer	Use of sub-optimal habitats	Unknown	OFF SITE: Prescribed burning in pinyon-juniper habitat <u>Cost:</u> Burning and seeding of herbaceous species in Ponderosa pine/grassland <u>Cost:</u> Burning in Grand fir, Douglas fir, ponderosa pine, bluebunch wheatgrass <u>Cost:</u>	Northern Arizona Northcentral Arizona Idaho, Arizona	McCulloch 1969 Kruse 1972 Keay and Peek 1980; Hungerford 1970	Deer density increased 36% within 1/4 km of the burned area but not beyond. Deer density increased 818% during three year period following wildfire but decreased with resumption of livestock grazing. Fire was related to increased palatability of certain species and deer preferred burned sites after wildlife. The use of prescribed burning in deer habitats such as found in the Bear Divide has not been widely documented, but appears worthy of experimentation. In Arizona, fires, logging, and windstorms combined to rehabilitate 10% of the mule deer summer range, which coincided with a 24% increase in the fawn crop. Pederson and

EXPLORATORY DRILLING

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Well Site Selection	Mule Deer	Use of sub-optimal habitats (cont'd)					Harper (1978) recommended using prescribed burning on deer summer ranges in former aspen types dominated by non-commercial timber in Utah. Thus, burning on summer range may be useful, as Julander et al. (1961) showed summer range quality can be limiting to deer in areas heavily grazed by livestock.
							Some may be reluctant to use fire to manipulate sagebrush used by deer in winter. However, sagebrush can become decadent, similar to old-aged forests, and a mosaic of successional stages may well be better habitat. A variety of forage species in addition to sage appears beneficial to deer (Carpenter et al. 1979). A mosaic of 5-10 acre stands can be created by burning in late winter or early spring (Neuenschwander 1980). Fire has produced mule deer increases in chaparral habitats in California (Biswell 1957, 1967).
				Herbaceous seedlings, shrub plantings on converted pinyon-juniper woodlands Cost: Nitrogen and lime fertilization on crested wheatgrass & Kentucky bluegrass pasture Cost: Urea fertilization of mountain mahogany, oak, and saltbush Cost:	Utah	Plummer et al. 1970	Manipulation areas produced 900% deer density increases and contributed to significant reduction damage to adjacent croplands.
				Chaining and other methods for conversion of pinyon-juniper woodland Cost:	Black Hills, South Dakota	Thomas et al. 1964	Nitrogen and lime both contributed to increased forage nutritive values and concomitant increased deer use.
				Establishment of dependable water sources in areas where none existed Cost: Plowing and seeding alfalfa and wheatgrass on sagebrush/greasewood winter range. Cost:	New Mexico	Anderson et al. 1974	Urea produced greater production in mountain mahogany mule deer use on oak range increased. No effects were observed with ammonium sulfate fertilization.
Well Site Selection	Pronghorn				Utah, New Mexico	Short et al. 1977; Terrel 1973	Both studies demonstrate low deer use of large clearings but the effects of habitat edge stimulate deer use.
					New Mexico	Wood et al. 1970	Mule deer density increased 550% after establishment of permanent water sources.
					Southeast Oregon	Reeher 1969, Heady and Bartolome 1977	Sagebrush was plowed in the spring followed by wheatgrass plantings in autumn and aerially spread alfalfa the next spring. Pronghorn density increased 220% in 8 years. Additional water sources may have contributed.

EXPLORATORY DRILLING

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Drill Site Selection	Pronghorn (cont'd)	Use of sub-optimal habitats (cont'd)		Fertilization of silver sagebrush/grassland winter range <u>Cost:</u>	Alberta	Barrett 1979	Pronghorn density increased 20% and sagebrush utilization increased 96% following nitrogen fertilization.
	Elk			Burning in Douglas fir, hemlock forests <u>Cost:</u>	Northern Idaho	Leege 1969	Elk utilization of browse increased up to 4000% compared with an unburned control after prescribed burning.
				Burning in cedar-hemlock forests <u>Cost:</u>	Northern Idaho	Asherin 1976	Elk density increased up to 77% on summer range and 380% on winter range 1-2 years after prescribed burning.
				Farmland fertilization <u>Cost:</u>	Northcentral Washington	Brown and Mandery 1962	Fertilization of 250 acres of pasture land intercepted and held elk away from adjacent croplands and contributed to decreased crop depredations.
				Nitrogen fertilization of sagebrush and bitterbrush stands <u>Cost:</u>	Utah	Bayoumi and Smith 1976	Bitterbrush and sagebrush browse increased twig production and elk utilization increased up to 155% after treatment with nitrogen fertilizer. Phosphorus proved not useful, alone or in combination with nitrogen.
				Burning or clear-cutting in aspen stands <u>Cost:</u>	Northern Wyoming	Mueggler and Bartos 1977; Bartos and Mueggler 1979	Moderate intensity burning in decadent aspen produced high sucker production that continued 2 years after the burn. Extensive elk use of treated sites has been observed but not quantified and compared to control areas.
					Intermountain West	Shields 1981	Clear cutting and prescribed burning have successfully been used to stimulate aspen sucker production. However, treated areas must be large enough to withstand subsequent increased use by browsing ungulates. No quantitative evaluation of increased use is provided.
	Moose			Fire in spruce-fir jackpine habitat <u>Cost:</u>	Northeastern Minnesota	Peek 1974; Irwin 1975	Moose density increased 300% two years after wildfire. Yearling immigration to the area was believed to be the initial cause for the density increase, followed by an increase in twinning rates by 3 years after wildfire.
				Fire in aspen habitat <u>Cost:</u>	Montana	Gordon 1976	Increased use of burned areas by moose was documented.
	General Wildlife Habitat	Habitat loss		Burning continuous stands of sagebrush to produce mosaic of successional stages and increase habitat diversity <u>Cost:</u>	Nevada	Klebenow 1973	Fire is recommended over herbicides to produce meadow/shrub mosaics and stimulate forb production.

EXPLORATORY DRILLING

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Drill Site Selection	Sage Grouse	Habitat loss (cont'd)		Strip spray sagebrush to produce meadow/shrub mosaic. Cost:	Idaho	Autenrieth 1969	Strip spraying in a relatively high precipitation zone created a meadow/shrub mosaic that was used substantially by sagegrouse broods. However, sagebrush control by spraying is generally not recommended to enhance sage grouse habitat (Braun et al. 1979).
				Plowing and reseedling sagebrush and wheatgrass and alfalfa Cost:	Southeast Oregon	Heady and Bartolome 1977	Sagebrush plowing and seeding (see Pronghorn, above) was believed responsible for increased sage grouse use.
				Water development: gallinaceous guzzlers Cost:	Sweetwater County, Wyoming	June 1968	Water guzzlers contributed to increased sagegrouse and other small game use of areas surrounding the water source.
	Desert Cottontail Rabbit			Pinyon-juniper conversion leaving down trees as cover along with shrubs Cost:	Southwest New Mexico	Kundaeli and Reynolds 1972	Habitat for cottontails was improved by leaving 70 to 90 down trees/acre in combination with living shrubs to promote cover. Trees act to suppress shrub growth and rabbit density decreases.
	Small Mammals			Burning sagebrush to increase small mammal density Cost:	Northwest Wyoming	McGee 1982	In general, habitat conversion by fire or chaining leads to greater small mammal densities but lower local species diversity. Opportunistic species such as deer mice and ground squirrels are most abundant following manipulations whether due to decreased competition from species with greater cover requirements (e.g. voles) or to opportunities for granivores and insectivores.
	Nongame birds	Local loss of prey base	Brink 1978; Oxley et al. 1974; Turkowski Reynolds 1970	Chaining with seeding in pinyon-juniper habitat Cost:	Northcentral Utah, Northwest Colorado	Baker and Frischknecht 1973; O'Meara et al. 1981	Treatment areas generally support fewer species and different nongame bird species than adjacent untreated areas. However, if species on treated areas are combined with those on untreated plots the total species diversity is increased compared to pre-treatment. The case for creation of habitat mosaics to increase bird species diversity is made repeatedly. Not all bird species respond positively to treatments (e.g. Brewer's sparrow decreases on sprayed sagebrush sites, Schroeder and Sturges 1975).
				Burning in sagebrush-grassland Cost:	Wasatch N.F., Utah	Castrale 1982	
				Burning in ponderosa pine Cost:	Prescott N.F., Arizona	Blake 1982	
				Chaining in pinyon-juniper habitat Cost:	Wasatch N.F., Utah; Northwest Colorado	Castrale 1982 O'Meara et al. 1981	
				See Small Mammals above	Northern Arizona	Turkowski and Reynolds 1970	
	Mammalian Predators and Raptors						Chaining in pinyon-juniper habitat served to increase four rodent species (also see examples above). Increases of both diurnal and nocturnal rodent species enriched the local prey base for raptors and other predators.

EXPLORATORY DRILLING

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECTS	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Drill Site Selection	Critical Wildlife Habitat (general)	Increased harassment (intentional or not) of animals on areas critical to breeding, reproduction, or survival during stress periods	Smith and Bloomfield 1980	Avoid locating well sites on or near key wildlife habitats <u>Cost:</u>	Oil and gas development, Alberta	Stubbs and Markham 1979; PRISM 1982; Smith and Bloomfield 1980	
	Big Game Winter Range		Lyon 1975 Ward 1973	Restrict drilling operations on occupied big game winter range to one geographic area that is visually and preferably structurally isolated from surrounding winter range. <u>Cost:</u> Avoidance of key habitat during crucial periods in wildlife species' life cycles: <u>Cost:</u>	Oil and gas development, Washington	Washington Dept. of Game 1980	This recommendation by Washington Department of Game is based on other documentation relating degree of big game response to the presence of visual and physical barriers such as vegetation (Ward 1973) or ridges (Lyon 1975). Decreased survival and reproduction as a result of harassment has been hypothesized (Geist 1971) but not well documented (See Task 2: Stress).
	Critical Big Game Winter Range	Critical habitat area loss, both actual (from the surface disturbances) and effectual (from visual, auditory, harassment, and disturbances) resulting in decreased survival during critical periods of intense stress	See Comments above	Avoidance from 10/15 to 5/15; <u>Cost:</u> Avoidance from 1/1 to 4/30 <u>Cost:</u> No occupancy from 5/15 to 6/30 <u>Cost:</u> No occupancy from 5/2 to 6/19 <u>Cost:</u> No occupancy from January to August <u>Cost:</u>	Oil and gas development, Alberta, Washington, Wyoming Shoshone N.F., Wyoming Kemmerer Resource Area, Wyoming Shoshone N.F., Wyoming Oil and gas development, Washington	Stubbs and Markham 1979; Smith and Bloomfield 1980; PRISM 1982; Washington Dept. of Game 1980; USDI BLM 1979 USDA, Forest Service 1982a USDI, Bureau of Land Management 1979 USDA, Forest Service 1982a Washington Dept. of Game 1980	
	Elk Calving Areas						
	Big Horn Sheep Lambing Areas						
	Big Game (general)	Use of sub-optimal habitat in lieu of disturbed critical winter range.		Off-site habitat manipulations to offset losses in traditionally used areas. (See above) <u>Cost:</u>	See above	See above	The wildlife habitat manipulations listed above under General Wildlife Habitat apply to Critical Habitat.

EXPLORATORY DRILLING

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECTS	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Drill Site Selection (cont'd)				General Wildlife Habitat for selected species and mitigative techniques). <u>Cost:</u>			
Well Site Selection	Raptor Nesting Sites	Disturbance during nesting periods may lead to nest abandonment or parents may spend more time away from the nest, thereby jeopardizing young survival.	Olendorff et al. 1980; Alldredge and Shickler, Unpub. data	Designate buffer zones around nest sites within which no occupancy is to occur during the species' nesting period. <u>Cost:</u>	Any development Raft River Valley, Idaho Lander County, Nevada Oil and gas development, Washington	Suter and Jones 1981; Washington Dept. of Game 1980	The use of buffer strips to protect nesting raptors is becoming a standard practice for threatened/endangered species as well as for more common species (Olendorff et al. 1980). Washington Department of Game (1980) recommends no drilling activities near any raptor nesting area until egg incubation begins.
				Off-site construction of artificial nesting sites and transplant of nesting pair. <u>Cost:</u>	Coal Mining, Powder River Basin Wyoming	Phillips and Beske 1982; Postovit et al. 1982	Limited experience with transplanting golden eagle nests away from advancing coal mines appears to be a promising mitigation technique for this species. However, Olendorff and Stoddard (1974) found that artificial nest sites may be unacceptable and unused by the target species and are often conspicuous in the transplant habitat resulting in increased disturbance and vandalism.
	Sage Grouse Leks	Disruption of sage grouse mating and reproductive process	See Amstrup 1977 for effects on sharp-tailed grouse	No disturbing activity on sage grouse strutting grounds from 3/1 to 6/15. <u>Cost:</u> No occupancy or disturbance within 1/4 mile radius of leks. <u>Cost:</u> Transplanting sage grouse to artificial or satellite leks off the proposed drill site. <u>Cost:</u>	Oil and gas development, Kemmerer Resource Area, Wyoming Oil and Gas development, Big Sandy/Salt Wells Resource Area, Wyoming Coal Mining, Campbell County, Wyoming; Southeast Montana	USDI, Bureau of Land Management 1979 USDI, Bureau of Land Management 1982a Tate et al. 1979; Eng et al. 1979	This is a potential lease stipulation currently applied by BLM. Movement of sage grouse to artificial or satellite leks may involve decoys and recordings of lek sounds as attractants. Similar vegetative and physical features to existing leks are recommended for the artificial lek site. Use of artificial leks is low but appears to increase after several years of effort.
	Sage Grouse Nesting Areas	Destruction of nests during ground clearing operations	Unknown	No occupancy or disturbance within 2 mile radius of leks during the nesting period. <u>Cost:</u>	Oil and gas development, Big Sandy/Salt Wells Resource Area, Wyoming	USDI, Bureau of Land Management 1982a	Gill (1965) and Martin (1970) demonstrated that 80% of all sage grouse nests were within a 2 mile radius of a lek. There are, of course, site specific differences depending on habitats.

EXPLORATORY DRILLING

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECTS	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Drill Site Selection	Sage Grouse Nesting Areas (cont'd)			Avoid any sagebrush control within a two mile radius (3 km) of leks and where live sagebrush cover is less than 20% and on shallow soils with low sagebrush. <u>Cost:</u>	Sagebrush control Colorado, South-east Idaho	Braun et al. 1977; Klebenow 1969 and 1970	Dependence of nesting sage grouse on sagebrush cover has been well documented. If off-site habitat improvement projects are planned in sagebrush stands, the possibility of nesting sage grouse in the area is a consideration.
	Nesting Waterfowl	Nest desertion, decreased hatching success possibly due to greater time spent by adults away from nest.	Barry and Spencer 1976	Avoid drilling during nesting period in important waterfowl areas. <u>Cost:</u>	Oil and gas development, Mackenzie River Delta, NWT	Barry and Spencer 1976	Studies in the Canadian arctic show significantly more nesting waterfowl and higher productivity on control areas away from oil drilling than on areas proximate to drilling. No firm conclusion was drawn but increased nest predation was suggested as the cause of decreased productivity near a drill rig since disturbed adults were more visible to predators. This is a hypothesis in need of testing.
				Potential stipulation specifying buffer strips along riparian areas and around aquatic resources. <u>Cost:</u>	Oil and gas development, Kemmerer Resource Area, Wyoming	USDI, Bureau of Land Management 1979	These stipulations are recommended to protect aquatic resources and may afford protection to nesting waterfowl. However, floodplains in the Kemmerer Resource Area are subject to development from other sources (e.g. El Caballo Subdivision near Evanston) and are the subject of concern (Lockman 1982).
				Off-site construction of artificial nesting structures for Canada geese. <u>Cost:</u>	Habitat Improvements, Bear River flood plain, Wyoming	Appel 1971 Bone 1973, Saul 1971	A variety of nesting structures used along the Bear River proved highly successful in stimulating Canada goose nesting use and brood production in areas that formerly did not support numbers of nesting geese.
				Protection of nesting water fowl with 100 meter buffer zone between well pad and high water mark of water body. Increase the buffer zone to 300 m for colonial nesters and trumpeter swans. <u>Cost:</u>	Oil and gas development, Alberta	Stubbs and Markham 1979	Barry and Spencer (1976) stated that whistling swans, white-fronted geese, Canada geese, and snow geese avoided a drilling rig in northern Canada more than other species. However, Stubbs and Markham (1979) provide no data upon which they are basing their recommendations.
	Black-footed ferrets; prairie dog towns	Elimination of Ferret food source or ferret mortality due to surface covering & compaction	Unknown	No surface occupancy on areas of known prairie dog towns. <u>Cost:</u>	Oil and gas development, Kemmerer Resource Area, Wyoming	USDI, Bureau of Land Management 1979	The potential for black-footed ferrets inhabiting the Kemmerer Resource Area is significant since skeletal remains have been discovered (Martin and Schroeder 1979, 1980).

EXPLORATORY DRILLING

COMMENTS ACTIVITY	SPECIAL CON- SIDERATION	POTENTIAL EFFECTS	DOCUMENTATION OF EFFECTS	POTENTIAL MITICA- TION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Drill Site Selection (cont'd)	Black-footed ferrets			Surface occupancy after search for Black-footed ferrets or sign. <u>Cost:</u>	Oil and gas devel- opment, Big Sandy/ Salt Wells Re- source Area, Wyo- ming	USDI, Bureau of Land Manage- ment 1982a	
	Burrowing Owls: Prairie dog towns	Mortality due to surface covering and ground com- paction; loss of nesting habitat.	Unknown	See Black-footed ferrets above. <u>Cost:</u>	Oil and gas devel- opment, Kemmerer Resource Area, Wyoming	USDI, Bureau of Land Manage- ment 1979	BIM (1979) states that existing leases may not be reoffered after expiration on known burrowing owl habitat.
	Bald Eagle communal winter roosts	Elimination of essential habitat characteristics (e.g. roosting areas, food re- source, thermal shelter) neces- sary for winter survival.	Stalmaster and Newman 1978; Mathisen 1968	ON SITE: Protection of winter roosts from all disturb- ances within one mile. Off-site habitat enhance- ment measures to affect increase and diversity of terrestrial and aquatic prey species. <u>Cost:</u>	Oil and gas devel- opment, siting railroad corridor, Kemmerer Resource Area, Wyoming	Jenkins 1982	Off-site mitigative measures include stream improvements to increase fish numbers and diversity, development of cover to enhance game bird and small game populations, and development of alternative perch sites through cottonwood plantings, river bank stabilization to reduce tree loss, and planting shield trees to provide buffers from disturbance (Jenkins 1982).
Well Site Selection	Critical Fisheries Habitat	Sedimentation of streams due to surface distur- bance and increased run- off. Sediments decrease egg and fry survival,	Cordone and Kelly 1961; Peters 1965; Gibbons and Salo 1973; Meehan 1974				Sediments prevent water flow through gravel beds and contribute to reduced spawning success of trout and other species dependent on intergravel space for egg and fry survival.
	Native Cut- throat Trout	hinders fry emer- gence from gravel decreases inver- tebrate food species and fills in beaver ponds and natural pools necessary to winter survival of		ON SITE: Avoid blad- ing, beaver dam disturbance, new road con- struction in Bear River (Bonneville) Cutthroat Trout drainages. <u>Cost:</u>	Oil and gas devel- opment, Kemmerer Resource Area, Wyoming	USDI, Bureau of Land Manage- ment 1979	

EXPLORATORY DRILLING

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECTS	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Well Site Selection	Native Cutthroat Trout (cont'd)	trout. Sediments also are cause for increased water temperatures and can reduce oxygen solubility.	Brown and Krygier 1967; Lantz 1971; Burns 1972; Ringler and Hall 1975; Hoss et al. 1979	Avoidance of poorly developed riparian zones with poor sediment trapping capabilities. <u>Cost:</u>	Recommended for Native Cutthroat Trout streams in Kemmerer Resource Area, Wyoming	USDI, Bureau of Land Management 1977	A recommended procedure although only qualitative evaluations of slope aspect and sedimentation potential are provided in this document. In California, Erman et al. (1977) showed direct correlation between riparian buffer strip width and increased aquatic habitat quality. When streamside vegetation is decreased, by whatever process, stream degradation proceeds from bank collapse, decreased channel stability, and bottom deposition (see Fish, Task 2 for a review).
				Avoid surface disturbance on slopes with sparse vegetation (south and west facing slopes) confining disturbance to north and east slopes with greater vegetation cover. <u>Cost:</u>	Same as above	Same as above.	
				Employ sediment traps in intermittent stream drainages below disturbances. <u>Cost:</u>	Same as above	Same as above	
				OFF SITE: Livestock exclusion from all or portions of sensitive riparian areas along cutthroat trout streams by fencing, seeding with unpalatable vegetation, or change timing of entry and exit to avoid watershed destruction. <u>Cost:</u>	Same as above	Behnke 1976; USDI, Bureau of Land Management 1977; Binns and Eiserman 1979	
				Disperse livestock away from sensitive riparian areas by developing off-stream water sources and salting sites. <u>Cost:</u>	Same as above	Same as above	Livestock grazing is detrimental to riparian and aquatic habitats and effects are reviewed in Task 2. Generally, any method used to exclude or regulate livestock use and eventual overutilization of riparian areas will benefit rejuvenation of riparian vegetation with concomitant improvements in aquatic habitat for trout.

EXPLORATORY DRILLING

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECTS	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Well Site Selection (cont'd)	Native Cutthroat			Protection of spring seeps from livestock trampling and compaction. <u>Cost:</u> Stream improvement structures such as in-channel boulders, stream bank riprap, to slow stream velocity. Beaver, indigenous or transplanted, have been recommended as stream improvement agents. <u>Cost:</u>	Same as above	Same as above	Spring seeps are an important source of water supplying sometimes minimum flows during critical drought periods and protection from livestock damage has been suggested.
				Stream improvement structures such as in-channel boulders, stream bank riprap, to slow stream velocity. Beaver, indigenous or transplanted, have been recommended as stream improvement agents. <u>Cost:</u>	Same as above	Smith 1980; Smith 1981	The importance of beaver pond-trout relationship has been emphasized by Call (1966) and beaver reintroduction with associated aspen plantings has been recommended as a rehabilitation measure for declining trout streams. Often, stream channelization is a procedure used in agriculture.
	Rare, Threatened Endangered Plants	Elimination of all or a portion of all the extant population	Unknown	On site avoidance of known populations <u>Cost:</u>	Oil and gas development, Kemmerer Resource Area, Wyoming	USDI, Bureau of Land Management 1979	Although BLM recognizes the presence of sensitive plant species in the Kemmerer Resource Area no special stipulations regarding protection has been found. Plant species proposed for threatened status are to be managed the same as plants on the Threatened and Endangered List (USDI, Bureau of Land Management 1979).
		Impaired viability and vigour of populations adjacent to disturbed sites due to fugitive dust and contaminated surface run-off.	Wilshire et al. 1978; Brink 1978	Construct well pad down slope from known populations. <u>Cost:</u> Construct well pad downwind (prevailing wind direction) from known population <u>Cost:</u>	Unknown	Unknown	Surface runoff and effects on downslope vegetation are recognized by BLM (1979) and deposition of sediments on vegetation downwind from surface disturbances (Wilshire et al. 1978; Brink 1978) are detrimental to vegetation survival.
				Off-site protection of known populations with livestock exclosures. <u>Cost:</u>	Livestock pastures Kemmerer Resource Area, Wyoming	Whiskey Basin Consultants 1982	Livestock grazing and trampling are cited as the cause of downward trends for two species of rare plants occurring in the Kemmerer Resource Area.
	Steep Terrain	Increased surface disturbance due to large areas of cut and fill slopes and areas dedicated to excess cut material stockpiling.	Stiller et al. 1980; Wright et al. 1978	Restriction of drill pad construction to slopes 30% or less. <u>Cost:</u> Directional drilling from less steep locations. <u>Cost:</u>	Oil and gas development, Kemmerer Resource Area, Wyoming	USDI, Bureau of Land Management 1979	
					Same as above	Same as above	Directional drilling is feasible only in a very few cases. Geology determines feasibility.

EXPLORATORY DRILLING

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECTS	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Well Site Selection (cont'd)	Steep Terrain			Stockpile cut-material on up-slopes or on flat terrain for access during recontouring and reclamation. <u>Cost:</u> Restriction of drill pad construction to slopes 30% or less <u>Cost:</u>	Oil and gas development, Kemmerer Resource Area, Wyoming	USDI, Bureau of Land Management 1979	
		Surface run-off, gulleying and below-site stream sedimentation (see Native Cutthroat trout, above).	See references under Native Cutthroat trout, above		Same as above	Same as above	Restricting construction to slopes of 30% or less may not be feasible in the Overthrust Belt.
				Construction of levees and water drainage facilities on the downhill side of the pad (see Site Preparation, below). <u>Cost:</u>	Oil and gas development, Washington	Washington Dept. of Game 1980	
Well Site Preparation	Critical Periods:	See above: Critical Wildlife Habitat	See above: Critical Wildlife Habitat	No occupancy from 5/15 to 6/30 <u>Cost:</u> No occupancy from 10/15 to 5/15 <u>Cost:</u>	Oil and gas development, Kemmerer Resource Area, Wyoming	USDI, Bureau of Land Management 1979	
	Elk Calving Period				Same as above	Same as above	
	Big Game Critical Winter Range Occupancy				Same as above	Same as above	
	Sage Grouse Strutting and Nesting Periods			No occupancy from 3/1 to 6/15 <u>Cost:</u>	Same as above	Same as above	
	Raptor Nesting Periods			No occupancy until incubation has begun. <u>Cost:</u>	Oil and gas development, Washington	Washington Dept. of Game 1980	

EXPLORATORY DRILLING

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECTS	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Well Site Preparation (cont'd)	Bald Eagle Winter Roost	Displacement from food and shelter resources critical to winter survival.	Stalmaster and Newman 1978; Mathisen 1968	No occupancy at least from 11/15 to 3/31 <u>Cost:</u>	Oil and gas development, Kemmerer Resource Area, Wyoming	USDI, Bureau of Land Management 1979	Jenkins' (1982) counts of bald eagles occupying the Woodruff Narrows roost for the dates shown.
	Frozen Ground	Unstable ground likely to slump during thaws with concomitant sedimentation.	Unknown	Limit drill pad construction to periods when ground is not frozen. <u>Cost:</u>	Same as above	Same as above	
	Periods of high Precipitation and surface runoff	Production of additional sediments and runoff that may alter local drainages.	See references under Well Site Selection: Critical Fisheries Habitat and Native Cutthroat	Avoidance of surface disturbance until soils are dry. <u>Cost:</u>	Same as above	Same as above	Same as above.
	Topsoil Salvage	Loss of topsoil for future reclamation and revegetation efforts.	Groenewald and Rehm 1980; Power et al. 1979	Topsoil stockpiling <u>Cost:</u>	Oil and gas development, Kemmerer Resource Area; Bridger-Teton N.F. Wyoming Coal Mining, Kemmerer, Wyoming	USDI, Bureau of Land Management n.d.; Oman and Connor 1980 Howard and Samuel 1979; Singleton and Williams 1979	BLM specifies stockpiling the top 12 inches of soil and marking it as topsoil. USFS recommends stockpiling enough topsoil for respreading on the entire site to a depth necessary for revegetation with appropriate species. The best source of indigenous seed appears to be from freshly stripped topsoil, viability decreases with length of time soil is stockpiled.
	Viability of indigenous seed and soil microflora in stockpiled topsoil	Native vegetation seed viability & rhizomes decreases with increased time of stockpiling	Howard and Samuel 1979; Singleton and Williams 1979	Keep topsoil stockpiled for shortest time possible <u>Cost:</u>			
				Separate stockpiling of topsoil to avoid mixing with non-seed containing layers. <u>Cost:</u>	Coal Mining, Wyoming, North Dakota	Beauchamp et al. 1975; Iverson and Wali 1982	Most viable seed is within the top two inches of topsoil. However germinating seeds are those of common secondary successional species rather than from local dominant species.
		Loss or reduction of mycorrhizal activity that would contribute to successful revegetation.	Reeves et al. 1979; Allen and Allen 1980	Stockpile topsoil for shortest time possible, preferably less than 9 months. <u>Cost:</u>	Oil and gas development, Kemmerer Resource Area, Wyoming	USDI, Bureau of Land Management n.d.	Fungal mycorrhizae form important symbiotic associations with plants and contribute to phosphorous, and water uptake (Shuman and Power 1981). Topsoil stockpiled suffers reduction of mycorrhizal activity. Reeves et al. (1979) in Colorado and Allen and Allen (1980) working in Wyoming both suggest decreased mycorrhizal activity in soils remaining unvegetated for over 1 year and point out colonizing plant species are often those not requiring mycorrhizae associations for growth. Logically, freshly stripped topsoil would be the best seed growth medium available.
				Use freshly stripped topsoil from well site being prepared to spread on well site being reclaimed. <u>Cost:</u>	Unknown	Unknown	

EXPLORATORY DRILLING

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECTS	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Well Site Preparation (cont'd)	Erosion of stockpiled topsoils and cut material.	Loss of topsoil for future reclamation and revegetation efforts.	Power et al. 1981 Schuman and Power 1980	Grading stockpile to low profile slopes. <u>Cost:</u>	Unknown	Unknown	Both slope and length of slope contribute to erosion of uncovered soils (BLM Manual 7317 and Musgrave 1947) and soil losses will decline with reduced slopes.
				Seeding stockpiled topsoil with a variety of species (e.g. grains and legumes). <u>Cost:</u>	Oil and gas development, Kemmerer Resource Area, Wyoming	USDI, Bureau of Land Management n.d.	BLM requires stockpiles remaining for more than 1 year to be seeded with an annual grain. However, seeding with a monoculture (e.g. crested wheatgrass) offers limited variety of mycorrhizae and thus may limit numbers of plant species capable of succeeding wheatgrass (Reeves et al. 1979, Aldon 1978).
				Short term covering stockpiles with netting and mulch. <u>Cost:</u>	Oil and gas development, Big Sandy/Salt Wells Resource Area, Wyoming	USDI, Bureau of Land Management 1982a	Covering stockpiled topsoil with some material is a current accepted BLM mitigation measure to reduce wind and water erosion. Covering, however, is likely to be more expensive than seeding.
	Salvage of cutbank material	Loss of fill material needed for site reclamation and recontouring.	Unknown	Stockpile excess cut material on up-slope or removal to flat site for stockpiling. <u>Cost:</u>	Same as above	Same as above	Stockpiled cut material is necessary for use in well site reclamation. For eventual retrieval of cut material, stockpiling on slopes above the cut or on flat ground facilitates reclamation. BLM (1982) recommendation was for roads but may also apply to pads
	Leveling well site with down-slope fill	Covering downslope vegetation.	Unknown	Use minimum amount of cut material as fill. (assuming attempt has been made to locate well pad on flattest possible terrain) <u>Cost:</u>	Oil and gas development, Washington	Washington Dept. of Game 1980	More cut material is generated in steep than flat terrain and more fill is needed to produce a level pad.
	Excess runoff from drill pad	Downhill stream sedimentation (see Cutthroat Trout, above)	See references under Critical Fisheries Habitat and Native Cutthroat Trout, above	Construct a berm around downslope side of drill pad with surface runoff directed by trenches to water retention features such as basins, contour trenches, contour furrowed slopes or shallow slopes. <u>Cost:</u>	Coal Mining arid west	Verma and Thames 1978	Retention of surface runoff and provision for its slow release are practices recommended for coal strip mining and have applicability to any surface disturbance where uncovered soil slopes are concerned.
					Oil and gas development, Washington	Washington Dept. of Game 1980	

EXPLORATORY DRILLING

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECTS	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Well Site Preparation (cont'd)	Excess runoff from drill pad			Conformation of drill pad shape to terrain contours. <u>Cost:</u>	Oil and gas development, Washington	Washington Dept. of Game 1980	This procedure is recommended for the strip mining industry in the analogous situation of contour terracing reclaimed spoils for moisture retention (Verma and Thames 1978). Land surfaces returned to original contours with irrigation of seeds produce less than 10% sediment yields than spoil ridges struck off in 15 ft. widths, seeded but not irrigated (Smith 1980).
Mud/Reserve Pit Construction	Placement of pits to avoid unstable ground and failure	Soil and water contamination with pit fluids.	See Mueller 1968; Millis 1969 and 1972	Construction of mud and reserve pits on cut ground and not on fill slopes. <u>Cost:</u>	Oil and gas development, Bridger-Teton N.F.: Big Sandy/Salt Wells Resource Area, Wyoming	USDA, Forest Service 1982a; USDI, Bureau of Land Management 1982a	While the Forest Service specifies mud pit placement on the upslope side of a pad, BLM proposes this constraint only with construction of pads on slopes of 25% or more (BLM 1982).
	Placement of pits to avoid overflow from surface water runoff	Same as above.	Same as above	Placement of pit away from natural surface drainages. <u>Cost:</u>	Same as above	Same as above	These mitigative measures are standard recommendations developed by the FS and BLM although not compiled together in any one document.
				Trench construction around uphill side of pit to divert surface runoff. <u>Cost:</u>	Same as above	Same as above	
				Piling snow downslope from pits. <u>Cost:</u>	Oil and gas development, Bridger-Teton N.F., Wyoming	USDA, Forest Service 1982a	The FS recommends management of snow accumulation to avoid runoff into the pit, no specific measures are supplied. Snowpiling and snow fence construction are two possible solutions.
				Construction of snow fences to divert snow accumulation away from slopes above pits. <u>Cost:</u>	Same as above	Same as above	Avoidance of pit construction within 25-year floodplains is consistent with Executive Order 11988, Floodplain management (BLM 1979).
	Prevention of mud pit dike failure	Same as above.	Same as above	Avoidance of mud pit construction within the flood plain of a stream. <u>Cost:</u>	Oil and gas development, Kemmerer Resource Area; Bridger-Teton N.F.	USDI, Bureau of Land Management n.d.; USDA, Forest Service 1982a	Both agencies specify construction of dikes in 8 inch lifts with watering and compaction of each lift.

EXPLORATORY DRILLING

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECTS	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Mud/Reserve Pit Construction (cont'd)				Excavation of pit to a depth where most pit fluids are below ground level. <u>Cost:</u>	Oil and gas development, Kemmerer Resource Area, Wyoming	USDI, Bureau of Land Management n.d.	Guidelines specify construction of 12 foot deep reserve pits with 1/2 the holding capacity below original ground surface.
	Prevention of seepage and percolation of pit fluids into aquifer.	Contamination of ground water and eventual contamination of down-slope drainages.	Same as above	Lining pits with impervious clay, vinyl (EPDM), or dacron scrim sheet to protect soils and ground water. <u>Cost:</u>	Oil and gas development, Washington	Washington Dept. of Game 1980	
	Wildlife & livestock entrapment in pits	Wildlife mortality	Flickinger 1980	Installation of stock tight fence around reserve pit <u>Cost:</u>	Oil and gas development, Kemmerer Resource Area; Bridger-Teton N.F. Wyoming	USDI, Bureau of Land Management n.d.; USDA, Forest Service 1982a	Fencing consisting of woven wire at least 28 inches high with two barbed wire strands above the woven wire or five strand barbed wire at specified intervals are recommended on three sides of the pit (BLM) and on all four sides if the pit remains over winter (FS)
		Waterfowl mortality	Tully and Boulter 1970; June 1973	Place flagging around reserve pit. <u>Cost:</u> Place streamers of flagging over and above fluid surface. <u>Cost:</u> Completely cover pits with wire mesh above the fluids in areas of high waterfowl use. <u>Cost:</u> Remotely timed and activated gas exploders and fireworks on long burning fuses. <u>Cost:</u> Use of model falcon, reflectors, and effigies on ponds as waterfowl deterrents. <u>Cost:</u>	Oil and gas development, Big Sandy/Salt Wells Resource Area, Wyoming Oil and gas development, Bridger-Teton N.F., Wyoming Oil and gas development, Washington	USDI, Bureau of Land Management 1982a USDA, Forest Service 1982a Washington Dept. of Game 1980	Waterfowl entrapment in reserve pits in Colorado (Tully and Boulter 1970) and Texas (Flickinger 1980) is well documented and the potential for local waterfowl mortality in pit fluids in the study area has been demonstrated by June (1973). Experimental evidence showing the effectiveness of one deterrent method over another is lacking.
					Mine Evaporation ponds, Lincoln County, Wyoming	June 1973	During Fall, 1973, 116 waterfowl were lost on the FMC Coke Plant evaporation pond south of Kemmerer. Gas exploders reportedly were the best deterrent when discharged at irregular time intervals.
					Oil sands extraction, Alberta	Boag and Lewin 1980	Experiments with the three types of deterrents indicated that (a manikin dressed in bright clothing) attached to a floating platform in the middle of the pond was most effective in reducing waterfowl use although some habituation to the effigy was evident.

ROADS, INCREASED HUMAN ACCESS

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Mud/Reserve Pit Construction (cont'd)	All of the above.	All of the above.	See above	Circulation of drilling fluids by self-contained portable units eliminating the need for reserve pits. <u>Cost:</u>	Oil and gas development, Bridger-Teton N.F., Wyoming	USDA, Forest Service 1982a	Recycling drilling fluids and/or containerizing eliminates the need for mud pits. (BLM 1979)
Construction	bobcat, fox, coyote, raptors	loss of denning areas in rock ledges loss of nest sites in rock ledges	Unknown	locate roads away from rock ledges <u>Cost:</u>	Oil and gas development, Michigan	Bennington et al. 1982	Predatory mammals returned in 2-4 weeks to the area.
	Big game winter range	Losses of animals through displacement and excess movements	Unknown, but see Task 2, STRESS	locate roads to avoid habitat designated as crucial <u>Cost:</u>	Oil and gas development, Wyoming Alberta	USDI, Bureau of Land Management 1979; Stubbs and Markham 1979	Few studies have determined actual effects of disturbance to wintering big game. However, it has been established that winter range is usually the critical limiting factor for maintaining healthy big game populations.
Traffic on oil roads	Big game	Quarter-mile strip of decreased use (displacement) each side of road effectively "removes" 320 acres per mile of road from much use by big game species.	Ward et al. 1973; Ward 1976	locate roads away from prime feeding areas on open meadows and slopes and along stream courses <u>Cost:</u>	Recreational use, Medicine Bow N.F., Wyoming	Ward 1973; Ward et al. 1976	Heaviest crossings of roads occur where desirable feeding sites occur. Traffic has little effect on big game beyond 400 yds. except that traffic has more of an effect on deer in shrubby habitats than in pine and juniper habitats (Roast and Bailey 1979).
	General Wildlife	Vehicle-animal collisions result in wildlife mortality and loss of personal property and perhaps human injury.	Ward 1982; Goodwin and Ward 1976; Arnold 1978; Wallmo et al. 1976	Restrict public access by locked and/or manned gates at main points. Also, impose speed limits in critical areas of concern. Also, erect 8 ft. fencing and use under-passes to reduce car-deer accidents <u>Cost:</u>	Oil and gas development, Washington Interstate 80, southcentral Wyoming	Washington Dept. of Game 1980 Ward 1982	Authorities can restrict public effects on wildlife to seasons when impacts are minor. It is useful to ensure state and federal agencies will have access for management purposes. Fencing forced over 1,000 deer to use machinery and box-type under-passes, reducing deer-vehicle accidents over 95%. Baiting (with alfalfa, e.g.), helped lure deer through under-passes the first time.

WELL SITE ACCESS

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Increased recreational access.	Snow-mobiles	Displacement of wildlife to poorer quality habitats; harassment of wildlife	Dorrance et al. 1975; Ferguson and Keith 1982	Road closures, using locked and/or manned gates <u>Cost:</u>	Recreational activity, Minnesota; Oil and gas development, Alberta	Dorrance et al. 1975 Stubbs and Markham 1979	White-tailed deer were displaced during weekends primarily, but came back to preferred areas during weekdays. Snow-mobiles were more of an influence on deer that were hunted.
	ORV's and reptiles & amphibians	Heavy mortality may be caused	Bury et al. 1977	Restrict speed, restrict access in migration areas. <u>Cost:</u>	ORV use, California; Oil and gas development, Washington	Bury et al. 1977; Washington Dept. of Game 1980	Biologists may be able to point out important migration routes from denning areas.
	illegal hunting	Could seriously reduce game numbers and reduce opportunities for legal hunters	Smith and Bloomfield 1980	Road closures; increase law enforcement personnel <u>Cost:</u>	Oil and gas development, Alberta	Stubbs and Markham 1979; Smith and Bloomfield 1980	This is one area where little seems to be known about impacts on wildlife populations. It may be useful to plan some efforts at evaluating the increased poaching and its effects on wildlife populations.
Road Construction	Improper placement of culverts	Prevent upstream migration of spawning fish	Tobo 1955; Edgington 1969; Meehan 1974	Place culverts at proper angles and elevation such that no waterfalls become a barrier to movement <u>Cost:</u>	Oil and gas development, Kemmerer Resource Area, Wyoming	USDI, Bureau of Land Management 1979	
	Sage Grouse strutting grounds	Direct mortality of grouse & abandonment of strutting grounds	Unknown	Avoid sage grouse strutting grounds <u>Cost:</u>	Coal Mining, Campbell County, Wyoming	Tate et al. 1979	Where activities destroy or extensively modify a key game bird breeding area, successful mitigation appears questionable, because artificial strutting grounds are rarely visited, but alternative grounds are used.
Access Road Construction:	General Habitat for all wildlife species.	Surface Disturbance of 1 to 3.3 acres per mile of road construction.	USDI, Bureau of Land Management 1979	ON SITE: Reclamation of roadway to native vegetation following cessation of use. <u>Cost:</u> Minimize disturbance area by constructing a single lane road, 14 ft. wide, with turnouts and widened curves. <u>Cost:</u> Utilize existing roads to eliminate additional surface disturbance. <u>Cost:</u>	Oil and gas development, Washington	Washington Dept. of Game 1980	A 16 to 18 ft. wide road, including drainage ditches on 1 or both sides, removes 1 to 3.3 acres of habitat per road mile. In the Kemmerer Resource Area access roads range from 32 to 50 ft. wide with disturbed acreage between 4 to 6.25 acres per mile (BLM 1979). Reclamation of unnecessary roads is stipulated by BLM and FS.
Roadway Location					Oil and gas development, Bridger-Teton N.F.	USDA, Forest Service 1982a	Where average daily traffic does not exceed 100 and design speeds are 20 mph or less, single lane roads with inter-visible turnouts are practical. Reduction to 14 ft. width would produce a minimal surface disturbance.
					Oil and gas development, Alberta	Stubbs and Markham 1979	

WELL SITE ACCESS

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
				Construct roads to provide for long-term use without the need for recurrent maintenance and reconstruction that may increase the area of surface disturbance. <u>Cost:</u>	Oil and gas development, Bridger-Teton N.F., Wyoming	USDA, Forest Service 1982a	Logically, the better the initial road construction the less subsequent activity is necessary to maintain and correct construction flaws. Regrading and improvements on curves and drainage ditches may cause additional surface disturbances.
Visibility by Traffic on access roads	Increase the effective area of the surface disturbance to render roadside habitats unused by sensitive species.	Perry and Overly 1976; Lyon 1975	Decrease visibility of access road traffic. (see below for species specific recommendations). <u>Cost:</u> Provide 100 m buffer zones around open habitat, e.g. meadows, clearcuts. <u>Cost:</u>	Oil and gas development, Alberta	Stubbs and Markham 1979	Location of both drill pad and roads within timber was believed to be responsible for minimal impacts on elk and moose on winter range. Lyon (1975) found that timber along roads served as effective visual barriers decreasing elk displacement. Likewise, Perry and Overly (1976) demonstrated roads through dense timber had little effect on elk compared to roads through open habitats (e.g. meadows). Ridges also serve as effective barriers to decrease disturbances on elk (Lyon 1975).	
				Same as above	Same as above		

WELL SITE ACCESS

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Roadway location	Elk (cont'd)	Traffic as a disturbance factor causes road avoidance and reduce use of habitat adjacent to roads.	Marcum 1976; Schultz and Bailey 1978; Rost and Bailey 1979; Hershey and Leege 1976; Morgantini and Hudson 1979	Construction of roads where potential cover (e.g. roadside vegetation) is available or where ridges effectively isolate the disturbance from elk use areas. <u>Cost:</u> Curve roads every 360m unless already dictated by terrain, thus preventing long lines of sight.	Oil and gas development, Alberta	Beak Consultants 1979	
		Noise associated with traffic may contribute to elk displacement from roadside habitat.	Ward et al. 1976	<u>Cost:</u> Locate roads on elevations above known use areas to avoid concentrating and amplification of sound in valleys.	Oil and gas development, Alberta	Stubbs and Markham 1979	Curving otherwise straight access roads is believed to decrease line of sight and may facilitate animal road crossing if approaching traffic is obscured. This practice is best suited to forested areas, not open prairies.
	Mule Deer	Traffic may affect deer distribution as it does elk.	Rost and Bailey 1979	<u>Cost:</u> See Elk, above.	Same as above	Same as above	Deer response to traffic on roads has been documented as avoidance (Rost and Bailey 1979, Ward et al. 1976) or habituation (Reed et al. 1975). The consensus is that mule deer are less affected by roads than elk (Perry and Overly 1976, PRISM Consultants 1982). However, this depends upon vegetation density in an area. Rost and Bailey (1979) found that more avoidance by deer occurs in open habitats as compared to forests. The greater impact of roads appears to be vehicle related mortality (see Access Road Use, below).
	Moose	Same as above.	Rolley and Keith 1980	Same as above.	Same as above	Same as above	Moose response to roads is poorly documented although Rolley and Keith (1980) noted moose further from roads than expected.
	Pronghorn	Same as above.	Reeve 1982; Sundstrom and Hepworth 1968; Riddle and Oakley 1973	Same as above.	Same as above	Same as above	Pronghorn reactions to roads and traffic have been recently documented (Reeve 1982). Animals show habituation where traffic volume is high but react vigorously to vehicles in low traffic areas. Primary effects of roads may come with associated fence lines and hinderance of pronghorn movements (Riddle and Oakley 1973, Sundstrom and Hepworth 1968).

WELL SITE ACCESS

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/LOCATION	REFERENCE	COMMENTS
	Big Game, Game and Nongame birds, game and nongame mammals	Use of suboptimal habitats.	See Well Site Selection, above	See Well Site Selection, Off-Site Mitigation Techniques <u>Cost:</u>			
	Aquatic Habitats, general for fish, amphibians, and aquatic furbearers.	Sedimentation due to runoff from roads can reduce aquatic habitat quality.	See Critical Fisheries Habitat and Native Cutthroat trout, above	Construct roads at least 500 ft. away from the annual high water mark of a stream or lake. <u>Cost:</u>	Oil and gas development, Bridger-Teton N.F., Wyoming	USDA, Forest Service 1982a	Sedimentation and habitat loss associated with road construction can reduce fish abundance (Whitney and Bailey 1959), invertebrate fish food (Barton et al. 1971, Brode et al. 1973, Barton 1977), and may interfere with beaver damming (Smith 1981). Buffer zones with sufficient vegetation to provide sediment traps appear helpful in maintaining aquatic habitat quality (Erman et al. 1977).
				Avoid roads within 100m of any water body. <u>Cost:</u>	Oil and gas development, Alberta	Stubbs and Markham 1979	
				Avoid construction of new roads in or through drainage bottoms. <u>Cost:</u>	Oil and gas development, Big Sandy/Salt Wells Resource Area, Wyoming	USDI, Bureau of Land Management 1982a	
				A zone of riparian vegetation left between the water body and construction zone can act as a sediment trap. <u>Cost:</u>	Oil and gas development, Washington Logging, California	Washington Dept. of Game 1980; Erman et al. 1977	See Erman et al. 1977
Stream Crossings: Use of Culverts		Accelerate water velocities with concomitant downstream channel downcutting and bank erosion. Greater water velocities may prohibit upstream fish migrations.	Cartman 1982; Tsui and McCart 1981; Tebo 1955; Edgington 1969; Meehan 1974	Culverts of sufficient size should be installed at proper angles to handle runoff and prevent sediment accumulation. <u>Cost:</u>	Oil and gas development, Kemmerer Resource Area, Bridger-Teton N.F. Wyoming	USDI, Bureau of Land Management 1979; USDA, Forest Service 1982a	Culverts large enough to a 10 year flood event within a 10 square mile watershed are recommended in the Kemmerer Resource Area. Large culverts would also provide slower velocities and decrease below-culvert downcutting.
				Use energy dissipating structures (e.g. boulders, riprap) below culverts. <u>Cost:</u>	Oil and gas development, Kemmerer Resource Area, Wyoming	USDI, Bureau of Land Management 1979	Riprap placed below culvert openings also decreases bottom downcutting.

WELL SITE ACCESS

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Roadway Location	Stream Crossings: Use of Culverts	Shallow depth in culverts may produce a migration barrier to fall spawning fish.	Dane 1978; Dryden and Stein 1975; Burns 1972	Culvert openings flush with stream bottom to avoid flow discontinuities. <u>Cost:</u> Preservation of natural stream bottom and banks using a bridge or pipe arch crossing. <u>Cost:</u>	Oil and gas development, Central Region U.S.A.	USDI, BLM, USGS and USDA, FS 1978	Surface use standards developed by three federal agencies provide specifications for culvert placement, alignment and construction for stream crossings and road ditch drainage.
	Removal of stream-side vegetation at road crossings	Increased sedimentation due to downstream erosion of denuded banks.	Tebo 1965; Narver 1970; Brown and Krygier 1971; Burns 1972; Erman et al. 1977	Revegetate stream banks upon completion of crossing and fencing to protect from livestock use. Fencing to 200 ft. back from each side of the stream is recommended. <u>Cost:</u> Protection of downstream banks with riprap structures, channel linings, or diversion jet-ties. <u>Cost:</u>	Oil and gas development, Kemmerer Resource Area, Wyoming	USDI, Bureau of Land Management 1979	BLM suggests revegetation immediately upon completion of crossings with temporary fencing to be removed after successful rehabilitation.
	Construction roads in steep terrain	Greater area of surface disturbance due to cut and fill requirements.	USDI, Bureau of Land Management 1982b	Removal of excess spoil (cut) material to flatter terrain for stockpiling rather than pushing excess on downhill side of cut. <u>Cost:</u>	Erosion Control Kemmerer Resource Area, Wyoming	USDI, Bureau of Land Management 1971	Protection of downstream banks from stream crossings is especially important during spring runoff when water velocities may be accelerated by culvert channelization, according to BLM.
		Long grades result in significant erosion down the slope of the road and drainage ditch and contributes to significant	Same as above	Construct drainage dips ("thank-u-mams") not more than 1000 ft. apart. <u>Cost:</u>	Road Construction, oil and gas development, Kemmerer Resource Area, Wyoming	USDI, Bureau of Land Management 1979 and 1982b	In cases where cutslopes are not extreme cut material may be stockpiled on the uphill side of the cut for future access.
					Oil and gas development, Central Region USA	USDI, BLM, GS and USDA, FS 1978	

WELL SITE ACCESS

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Roadway Location	Construction of roads in steep terrain (cont'd)	sedimentation in streams.	Same as above	Drainage ditch <u>Cost:</u> Culvert spacing ranging from 1000 ft. on 2% grades to 250 ft. on 8-10% grades. <u>Cost:</u> Limit road grades to 8% or less. <u>Cost:</u>	Same as above Same as above Same as above	Same as above Same as above Same as above	
	Critical Wildlife Habitat (General)	Increased harassment (intentional or not) of animals on areas critical to breeding, reproduction, or survival during stress periods.	See References in Task 2 - STRESS	Roads to be located on ridgelines rather than cut-slopes. <u>Cost:</u> Access road not located on or near key wildlife habitats. <u>Cost:</u>	Oil and gas development, Big Sandy/Salt Wells Resource Area, Wyoming Oil and gas development, Alberta	USDI, Bureau of Land Management 1982a Stubbs and Markham 1979	Roads constructed on Ridgelines can conflict with other mitigative activities (see Elk, above). Siting roadway locations are constrained by the same stipulations as well as pad locations. For on site mitigative measures see Drill Site Selection, Critical Wildlife Habitat.
	Big Game Winter Range						
	Critical Big Game Winter Range						
	Elk Calving Areas						
	Big Horn Sheep Lambing Areas						
	Big Game Migration Routes						
	Raptor Nesting Sites	See Well Site Selection, Critical Wildlife Habitat for species specific on-site and off-site mitigative procedures, references, and comments.					
	Sage Grouse Leks						

WELL SITE ACCESS

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Roadway Location (cont'd)	Sage Grouse Nesting Areas Nesting Waterfowl Areas Black-footed Ferrets Burrowing Owls Bald Eagles Winter Roosts Native Cut-throat Trout Streams Rare Plants						
Roadway Construction	Vegetation Clearance, disposal of slash	Stockpiling or windrowing slash may create barriers to big game movement.	Lyon and Jensen 1980	Removal of slash, especially in forested areas, to off-site dumps or burial areas. Cost: Retain slash (stockpiling) for use as wildlife cover during road reclamation. Cost: Minimize height and depth of slash piles to .5 m. Cost: Construct roads along natural edges to avoid excess vegetation removal.	Oil and gas development, Bridger-Teton N.F., Wyoming Oil and gas development, Kemmerer Resource Area, Wyoming Oil and gas development, Alberta Oil and gas development, Bridger-Teton N.F., Wyoming	USDA, Forest Service 1982a USDI, Bureau of Land Management 1979 PRISM 1982 USDA, Forest Service 1982a	Slash has been shown to improve use of forest opening by mule deer.
	Critical Periods: Wildlife	Disruption of Wildlife activities critical to survival	See Well Site Preparation: Critical Periods above	Cost: See Well Site Preparation, Critical Periods, above Cost:			

WELL SITE ACCESS

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Roadway Construction	Frozen Ground	Unstable ground is likely to slump during thaws with concomitant sedimentation.		See Well Site Preparation, Critical Periods, above. <u>Cost:</u> Same as above.			
	Periods of high precipitation and runoff	Production of additional sediments and runoff that will alter local drainages.					
	Stockpiling topsoil and cut material for later use in road reclamation	Loss of inaccessibility of materials needed for recontouring and reclamation.		See Well Site Preparation, Topsoil Salvage, Salvage of Cutbank Material. <u>Cost:</u>			
Access Road Use	Fugitive dust from unpaved roads	Reduction of nesting birds in the dust shadow of roads.	Brink 1978; Hanley et al. 1980	Pave access roads (if these are temporary, this will conflict with road reclamation. Also see Reptiles, below). <u>Cost:</u> Road watering, coating with oil, surface penetrating chemicals, etc. <u>Cost:</u> Speed limit controls on access roads. <u>Cost:</u> (Note: all methods are potential mitigative solutions to ameliorate these effects). <u>Cost:</u>	Oil and gas development, Washington	Washington Dept. of Game 1980	Washington Department of Game (1980) lists paving as 85% efficient in reducing road dust compared with only 30% for frequent watering. Paving may conflict with reclamation goals.
		Early green-up of roadside vegetation due to dust coating snow (with lower albedo and higher heat adsorption) and higher use of road sides by wildlife (see Vehicle Related Mortality below).	Brink 1978	Same as above	Oil and gas development, Kemmerer Resource Area, Wyoming, Washington	USDI, Bureau of Land Management 1979; Washington Dept. of Game 1980	Wyoming DEQ does not permit application of wastewater without a permit. Analysis of wastewater is required. Road watering is probably least expensive and the most recommended procedure.
		Air-borne dust may present respiratory problems to wildlife residing near roadways.	Simmons et al. 1981; Spraker and Hibler 1977	Same as above.	Same as above	Same as above	Dust control efficiency increases from 25% to 30 mph to 80% at 15 mph (Washington Department of Game 1980). Speed limits are difficult to control. Brink (1978) noted deposition of dust on snow to at least 450 m downwind of an Alaska haul road. Vegetation along the road flowered and expired earlier than plants distant to the road due to earlier snow melt. Hanley et al. (1980, in Bromely 1982) noted reduced shorebird nesting density along roads to be partially caused from dust and Simmons et al. (1981) noted dust accumulations in the lungs of necropsied big horn sheep chronically exposed to dust.

WELL SITE ACCESS

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Access Road Use	Vehicle Related Collisions	Wildlife Mortality	Arnold 1978; Wallmo et al. 1976; Ward et al. 1980	Reduce traffic volume and regulate traffic speeds, (e.g. through car pooling or common carrier) especially during darkness. <u>Cost:</u> Construction of 8 ft fencing and roadway underpasses. <u>Cost:</u>	Oil and gas development, Washington	Washington Dept. of Game 1980	Monitoring road related wildlife mortality will point out where especially vulnerable areas are for installation of warning signs, speed limit postings, or other mitigative alternatives listed below. Certainly, limiting access to only essential personnel will reduce the probability of roadkilled wildlife, (see Allen and McCullough 1976).
	Deer (and other ungulates)				Oil and gas development Bridger-Teton N.F., Wyoming	USDA, Forest Service 1982b	
					Interstate 80, southcentral Wyoming	Ward 1982	
				Planting roadside with unpalatable vegetation to discourage deer use of road rights of way. <u>Cost:</u> In timbered areas, leave no clearance between road and forest edge. <u>Cost:</u>	Oil and gas development, Alberta	PRISM Consultants 1982	
				Roadsurfacing or dust abatement measures to prevent early green-up of snow covered roadside vegetation due to covering with dust. <u>Cost:</u> Same as above.	Same as above	Same as above	
					Same as above	Same as above	
	Medium size and small mammals	Same as above.	Oxley et al. 1974; Kozel 1977		Same as above	Same as above	Brink (1978) noted early vegetation growth on dust covered road sides and Regelin and Wallmo (1975) have used carbon black to accelerate snowmelt on winter forage. Studies dealing with explicit relationships between road dust, vegetation use and wildlife mortality have not been found.
	Road killed animals	Attraction to predators and scavengers, including bald eagles, increasing risks of vehicular collisions.	Unknown	Removal of all carrion well away from roads. <u>Cost:</u>	Bald eagle winter roosts, Woodruff Narrows, Wyoming	Jenkins 1982	Most road types studied provide barriers to small mammals but not to medium size rodents and mustelids (Oxley et al. 1974; Kozel 1977). The importance of mule deer carrion to wintering bald eagles was documented in the Woodruff Narrows roost area and made removal of road killed carcasses a logical program.

WELL SITE ACCESS

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Access Road Use (cont'd)	Snow Removal	banks created by snow plowing may restrict big game movements across roads and may trap animals in the road with no ready escape route.	Unknown	Limit snow banks to depths and provide cuts in the banks. <u>Cost:</u>	Oil and gas development, Alberta	PRISM Consultants 1982; Smith and Bloomfield 1980	This recommendation is based on elk and deer response to logging slash piles, deer movements in snow, and from observations of big game use of snow plowed roads. However, it has not been demonstrated that big game will use snowbank cuts when confronted by a vehicle.
		Increased access to recreationists and ORV use resulting in off-road habitat destruction and wildlife disturbance.	Wilshire et al. 1978; Eckert et al. 1979; Baker and Lafren 1979	Same as above.	Same as above	Same as above	ORVs impact vegetation directly and indirectly (Wilshire et al. 1978) by compacting soils and decreasing water infiltration and increasing runoff (Eckert et al. 1979, Baker and Lafren 1979). Usually, out-of-vehicle humans produce greater escape response than the vehicles (Kucera 1976, Schultz and Bailey 1978, Ward et al. 1972).
Access by Aircraft	Helicopter	Extreme wildlife response to helicopters compared to other modes of access.	MacArthur et al. 1982; Luz and Smith 1976; USDI 1976 (in Bromley 1982)	Mountain goats, big horn sheep; maintain flight altitudes below levels at which animals graze. <u>Cost:</u>	Oil and gas development, Alberta	Stubbs and Markham 1979	Theory has it that helicopter or other disturbances below the levels of goats and sheep are less intimidating to them than flying above the animals. This appears to be true with Dall sheep. (USDI, 1976 in Bromley 1982).
			Barry and Spencer 1976	Other wildlife: maintain flight corridors to provide areas of certainty, i.e. wildlife may habituate to disturbances that are more regular and definable in space. <u>Cost:</u> Nesting waterfowl Use of fixed-wing aircraft may decrease displacement (albeit, use more surface area for landing strips) <u>Cost:</u>	Same as above	Same as above	Geist (1971) maintains that habituation by ungulates to disturbances will occur if the animal is able to predict when and where the disturbance will happen. If populations have been hunted from the air, escape response is significantly greater (e.g. wolves, USDI, 1976 in Bromley 1982).
					Oil and gas development, Mackenzie River Delta, NWT	Barry and Spencer 1976	The differential response of waterfowl to fixed-wing aircraft has been hypothesized but remains to be verified.

WELL SITE & FIELD DEVELOPMENT FACILITIES

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Electrical Transmission Lines	Perching Raptors	Raptor Electro-cution	Olendorff et al. 1981; Nelson 1978	Reduction of elec-trocution poten-tial through design modifica-tions that change distances between phase conductors to greater than raptor wingspan and reduce prob-ability of simul-taneous contact with phase and ground conductors Cost: Use of structures such as perch guards to dis-courage raptor use of cross-arms Cost: Use of structures such as perch guards to dis-courage raptor use of cross-arms	Raptor Management	Olendorff et al. 1981; Nelson 1978	Between 70 and 90% of all raptor electrocutions are golden eagles. Widening the distance between phase conductors based on golden eagle wingspan would accommodate smaller species.
	Location of Trans-mission Lines	Raptor Electro-cution	Same as above	Avoid rights-of-way siting in areas of known golden nests and along water courses and lakes where bald eagles are known to congre-gate. Cost: See Pipelines, below, and Roads, above.	Same as above	Same as above	Perch guards and anti-perching devices may be more effective if alternate perch sites are available nearby.
	Burial of Transmis-sion Lines	Surface distur-bances	Same as above	Locate transmis-sion lines and buried lines along existing rights-of-way. Cost: See On-Site and Off-Site mitiga-tive alternatives above.	Oil and gas devel-opment, Bridger-Teton N.F., Wyoming	USDA, Forest Service 1982a	Olendorff et al. (1981) suggests that buried transmission lines provide a low benefit-to-cost ratio. However, in wilderness situations, burial may be desirable to limit obtrusions.
					Oil and gas devel-opment, Central Region USA	USDI, BLM, GS, and USDA, FS 1978	Logically, disturbances can be reduced if rights-of-way serve multiple functions.
Pipelines, Location	General Wildlife Habitat	See, Well Pad Location and Access Road Location, above	See Well Pad Location and Access Road Location, above	Same as above			
	Critical Wildlife Habitat	Same as above	Same as above	Same as above			

WELL SITE & FIELD DEVELOPMENT FACILITIES

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Pipelines, Location (cont'd)	Steep Terrain	Potential for excessive erosion and runoff increases with slope.	See Roadway Location: Steep Terrain, above	Pipeline routes, as with roads, following natural contours as much as possible and steep slopes avoided. <u>Cost:</u> Pipeline routes to coincide with road rights-of-way to reduce surface disturbance. <u>Cost:</u> Double wall construction of pipelines crossing waterways. <u>Cost:</u> Monitoring systems for leaks, especially at water crossings, with emergency valves to stop flow. <u>Cost:</u> Confine area of disturbance to 30 ft. within maximum right-of-way width of 50 ft. <u>Cost:</u> Unless a road is planned to parallel the pipeline, limit travel lane disturbance to clearance of vegetation with brush blade instead of dirt blade. Avoid any disturbance to soils and plant roots where possible. <u>Cost:</u>	Oil and gas development, Central Region USA	USDI, BLM, GS, and USDA, FS 1978	See Transmission Lines, above. Since pipelines containing H ₂ S are potentially hazardous to humans, these are routed away from roads and other areas used by humans. Generally, pipelines crossing streams or wetlands are discouraged by the leasing agency during the permit application process. Current pipeline stipulations for unitized oil and gas fields. Same as above.
	Stream Crossings	Potential for pipeline breaks and pollution of aquatic environment.	Strickland 1980		Same as above	Same as above	
					Oil and gas development, Washington	Washington Dept. of Game 1980	
					Same as above	Same as above	
Pipelines, Construction	Surface disturbance	Loss of wildlife habitat.	See Roadway Location and Well Pad Location, above		Oil and gas development, Rock Springs District, Wyoming	USDI, Bureau of Land Management n.d.	
					Same as above Central Region USA	Same as above USDI, BLM, GS, and USDA, FS 1978	

WELL SITE & FIELD DEVELOPMENT FACILITIES

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Pipelines Construction (cont'd)	Use of topsoil during reclamation	Loss of topsoil and/or mixture with potentially sterile or deleterious subsoils.	See Well Site Preparation, above	Separate topsoil from subsoil during excavation and stockpiling. <u>Cost:</u> Stockpile all excavated materials on uphill side of trench. <u>Cost:</u> Stockpile all brush and slash for use as wildlife cover during reclamation. <u>Cost:</u>	Same as above	Same as above	Same as above
Pipelines Reclamation	Use of Stockpiled Topsoil as seed growth medium	The longer topsoil is stockpiled the less likely native plant species are to become reestablished. Secondary successional species (weeds) are likely to predominate.	See Well Site Preparation, above	Reduce the stockpiling time to a minimum. <u>Cost:</u>	Oil and gas development, Big Sandy/Salt Wells Resource Area, Wyoming	USDI, Bureau of Land Management 1982a	Regrading and reclaiming excavated material is more efficient if placed in an easily retrievable location.
	Replacement of excavated materials in pipeline trench	Sinking of fill material with eventual gulley formation and erosion problems.	Stiller et al. 1980; Groenewold and Rehm 1980	Compaction of all fill in trenches during backfilling. Filled trenches monitored to detect settlement problems. <u>Cost:</u>	Oil and gas development, Rock Springs District, Wyoming	USDI, Bureau of Land Management n.d.	If brush and slash do not present problems as migration barriers to big game, it can be used as cover for small game and nongame mammals (Kundaali and Reynolds 1972) if spread out over the recontoured area following seed application.
	Preparation of ground surface for proper binding of topsoil	Loss of topsoil and seeds due to water and wind erosion.	May et al. 1971; Wight and Siddoway 1972; Wright et al. 1978	Deep chiseling parallel furrows on the contour to loosen compacted, recontoured surfaces. <u>Cost:</u>	Oil and gas development, Central Region	USDI, BLM, GS, and USDA, FS 1978	See Comments under Well Site Preparation, above
	Surface Treatments	See, Well Site/Roads Abandonment, below			Coal Mining, arid west	Verma and Thames 1978	Compaction of backfilled materials with watering would probably decrease future settling problems but the expense and transportation of water is likely to be prohibitive.
	Vegetation Establishment	See, Well Site/Roads Abandonment, below					Chiseling of compacted subsoils not only serves as a means of binding re-spread topsoils but also allows for plant root development that may otherwise be restricted.

WELL SITE & FIELD DEVELOPMENT FACILITIES

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Wastewaters Associated with Drilling	Saltwater/ Brine	Seepage of salt water from impoundments with deleterious effects on soil, terrestrial vegetation, and aquatic habitats.	De Jong 1980	Containment of saltwater/brine in evaporation ponds constructed and maintained to the same standards as mud pits. <u>Cost:</u>			Both Wyoming DEQ (1978, n.d.) and Wyoming Oil and Gas Commission (1982) provide regulation and guidelines for surface storage, disposal, and surface discharge of waste waters associated with drilling and production. These regulations call for specified analysis of all water planned for use or disposal by the industry. Brine and oil contaminated soils present significant reclamation problems unless proceedings are followed.
				Containerize waste for removal from the site and disposal at authorized sites. <u>Cost:</u>	Oil and gas development, Bridger-Teton N.F., Wyoming	USDA, Forest Service 1982a	
				Injection down dry wells to subsurface layers containing water of equal or poorer quality. <u>Cost:</u>	Oil and gas development, Washington	Washington Dept. of Game 1980	
				No discharge into ground or surface waters. <u>Cost:</u>	Same as above	See comments, above	
Tanks and Containers For Produced Oil	Skim ponds	Same as above	Millis 1969 and 1972	Use of recovered water for dust control on access roads. <u>Cost:</u>	Oil and gas development, Bridger-Teton N.F., Wyoming	USDA, Forest Service 1982b	As above, surface discharge is regulated by several agencies. Water extracted from crude oil (Blankenship and Larson 1978) and drilling fluid mixtures (Miller and Pesaran 1980) may inhibit plant growth.
	Location	Additional habitat lost in area of drilling.	See Roadway and Drill pad Locations, above	Unitizing tank batteries off drill pad sites with feeder lines from as many wells as possible. <u>Cost:</u>	Oil and gas development, Washington	Washington Dept. of Game 1980	It is unknown whether or not unitizing tank batteries is practiced.
	Open-pit storage	Fire hazards and soil contamination from stored oil.	De Jong 1980	All oil produced or transported to be stored in on-site tankage. <u>Cost:</u>	Oil and gas development, Wyoming	Wyoming Oil and Gas Commission 1982	Except in emergencies, no oil storage in open earthen reservoirs is permitted.
	Collection of combustible gases	Risks of fire and explosions with destruction of wildlife habitat due to fire and	Unknown	Use floating roof on storage tanks to eliminate gas collection space. <u>Cost:</u>	Oil and gas development, Washington	Washington Dept. of Game 1980	Floating roofs may produce fire potential if seals allow escape of combustible gas from tanks.

DRILL SITE & FIELD DEVELOPMENT FACILITIES

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
	Collection of Combustible gases (cont'd)			Ignition sources (e.g. heater treaters) spaced at 150 ft. from storage tanks. <u>Cost:</u>	Oil and gas development, Washington	Washington Dept of Game 1980	
Use of Surface or Sub-surface	Dewatering of waterways	Decrease water levels and potential elimination of aquatic habitats.	Unknown	Use water from deep aquifers that do not feed surface springs or seeps. <u>Cost:</u>	Same as above	Same as above	
				Transport water to drilling sites by truck or pipelines from approved sources. <u>Cost:</u>	Same as above	Same as above	
Use of generators, compressor stations and pumps.	Noise	Displacement of wildlife from areas surrounding noise source.	USDI 1976 in Bromley 1982	House generators, pumps and compressors to reduce noise. <u>Cost:</u>	Same as above	Same as above	USDI (1976, in Bromley 1982) shows most wildlife react to gas compressor station noise and that the response increases with increased station horsepower. The effect on wildlife is not fully known.
				Provide maximum noise reduction mufflers on all engines. <u>Cost:</u>	Same as above	Same as above	USDA, FS (1982a) specifies noise limits of 65 dB 100 ft. from the source in mitigation of impacts on recreational activities but provides no similar guideline for wildlife, although noise sources greater than 70 dB may not be permitted within 3 miles of bald eagle nests or peregrine falcon eyries.
				Use electric motors rather than diesel engines. <u>Cost:</u>	Same as above	Same as above	
				Site stationary noise sources in areas where topography may act as a sound barrier. <u>Cost:</u>	Same as above	Same as above	See Well Site Location, above.
				Limit engine operation to daylight hours if possible. <u>Cost:</u>	Same as above	Same as above	
Crew Camps/ housing	Garbage	Attraction of predators and scavengers to areas with increased human (Cont)	Eberhardt et al. 1982; Klein 1979	Use high intensity smokeless incinerators. <u>Cost:</u>	Oil and gas development, Central Region USA	USDI, BLM, CS, and USDA, FS 1978	Generally, permits are needed for burning.

WELL SITE & ROAD ABANDONMENT

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Crew Camps/ housing (cont'd)	Garbage	confrontations (especially with bears).	Chester 1980; Klein 1979	Bury garbage in pits with lids or screens to prevent wildlife entrapment or wind dispersal. <u>Cost:</u> Removal of garbage to at least 1 mile off-site. <u>Cost:</u> Location of crew camps off-site. <u>Cost:</u> Use of same housing area by several crews.	Oil and gas development, Rock Springs District, Wyoming	USDI, Bureau of Land Management n.d.	BLM (n.d.) specifies trash pits deep enough to be buried with at least 3 ft. of fill.
	Location	Increased surface disturbance and high activity/ recreation levels in camp area and surrounding areas	Smith and Bloomfield 1980	Unknown	Oil and gas development, Alberta	Stubbs and Markham 1979	Camp garbage and bear conflicts are also addressed by USDA (1982a).
Mud/Reserve Pit Reclamation	Drilling Fluids remaining in the pit	Seepage to soils and drainages with contamination of terrestrial and aquatic habitats.	Unknown	Leave fluids in pit for water evaporation. <u>Cost:</u> Use spray evaporators to augment natural evaporation. <u>Cost:</u> Broadcast spray fluids on vegetation away from streams. <u>Cost:</u> Containerize pit contents and transport to authorized disposal sites. <u>Cost:</u>	Oil and gas development, Bridger-Teton N.F., Wyoming	USDA, Forest Service 1982a	Mud pits left to evaporate during winter might be enclosed on all four sides and cover pond with flagging or netting to prevent waterfowl access (Wyoming DEQ 1978). Typically, mud pits, because of solutes present, are the last water bodies to freeze and may be attractive to migratory waterfowl (Washington Department of Game 1980).
					Same as above	Same as above	Use of pit waters in revegetation or broadcast spray operations needs a permit to construct a wastewater treatment (land application) facility (Wyoming DEQ n.d.).
					Same as above	Oman and Connor 1980	One well site using a dry mud separation system (Baroid system) with less needed reserve pit capacity than most other sites produced eighty-five 3,000 gallon tank truck loads of fluids (Oman and Connor 1980). Wyoming DEQ (n.d.) provide a list of authorized reserve pit disposal sites.
				Pump fluids down drill hole (if well is dry). <u>Cost:</u> Use treatment methods to separate water from dissolved solids such as the Lectro Clear Separation Process (Newpark Waste Treatment Systems). <u>Cost:</u>	Same as above	USDA, Forest Service 1982b	Fluids pumped down wellbore require MMS approval.
					Oil and gas development, Louisiana	SOLOCO 1981	Waste waters (pit water) and settled drilling muds may be treated by a portable facility to produce water with 96 to 99% of all suspended solids, oil/grease, and heavy metals removed as well as a cake of mud with 65 to 72% of the moisture removed. The process does not reduce Chloride to an acceptable level (SOLOCO 1981).

WELL SITE & ROAD ABANDONMENT

COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Replacement of Cut Materials	Shaping land to compatible contours & stable slopes	Excessive runoff and erosion where deep soils on steep slopes provide potential for gulley formation.	Verma and Thames 1978; Wight and Siddoway 1972 Stiller et al. 1980	Grade replaced material to conform with surrounding topography in the gentlest slopes as possible. <u>Cost:</u>	Oil and gas development, Central Region; Road Corridors	USDI, BLM, GS and USDA, FS 1978; Wright et al. 1978	Stiller et al. (1980) point out that complex slopes consisting of an upper convex portion a middle straight segment, and lower concave slope mirror natural hillslopes and spread erosion over the entire hillside. USDI, BLM et al. (1978) specifies reduction of cut and fill slopes to a minimum of 3:1. Wright et al. (1978) suggest slopes no steeper than 1.5:1 depending on exposure, substrate and precipitation regimes. They recommend slopes of 3:1 to be stair-step graded, left rough, or grooved.
				Contour furrow and contour trenches to reduce erosion-al energy and increase infiltration. <u>Cost:</u>	Same as above	Same as above	Verma and Thames (1978) recommend contour furrows 10 to 30 cm deep and spaced up to 1.5 m apart. On flat, short-grass prairie contour furrows and dykes were cited as contributing to greater forage production (Hubbard and Smoliak 1953). Contour furrowing at 3 to 5 foot intervals in medium to fine textured soils produced greatest vegetation responses of several treatments used with salbrush responding most favorably to the treatment (Branson et al. 1966). Likewise, Wight and Siddoway (1972) found that surface treatment (contour furrowing, scalping, pitting and miniature fallowing produced more than 100% increased precipitation use efficiency on soils with low infiltration capacities.
				Construct contour terraces to break up runoff slope and increase water retention and slow release runoff. <u>Cost:</u>	Same as above	Same as above	USDI, BLM et al. (1978) recommends terrace width equal to one blade width, should slope 1 to 2% and be inclined toward cut slope.
Burial of Slash and other Scrap Materials	Subsidence of replaced materials	Subsidence may disturb any slope stability that has been achieved and create new erosional patterns.	Stiller et al. 1980; Groenewald and Rehm 1980	Shallow pit placement on recontoured slope for increasing infiltration. <u>Cost:</u> Refrain from burying degradable materials in fill areas. <u>Cost:</u>	Coal Mining Montana Oil and gas development, Bridger-Teton, N.F., Wyoming	Hodder 1975 Oman and Connor 1980	Shallow pits or gouges have been shown to increase water storage in the upper four feet of soil over such treatments as surface chiseling or dozer basins. Stiller et al. (1980) report that mine overburden undergoes a 20 to 30% expansion during storage and, although premining densities may never be realized, contraction and subsidence of replaced overburden is a real possibility (Groenewald and Rehm 1980). Burial of degradable slash (Oman and Connor 1980) may aggravate the problem.

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COMPONENT ACTIVITY	SPECIAL CONSIDERATION	POTENTIAL EFFECT	DOCUMENTATION OF EFFECTS	POTENTIAL MITIGATION ALTERNATIVES	SITUATION/ LOCATION	REFERENCE	COMMENTS
Preparation of Ground Surface Prior to Topsoil Spreading	Developing a surface for proper binding of topsoil	Loss of topsoil and seeds due to water and wind erosion.	Mny et al. 1971; Hodder 1975; Schuman et al. 1980	Deep chiseling parallel furrows on the contour to loosen compacted recontoured surfaces. <u>Cost:</u>	Coal Mining, arid west	Verma and Thames 1978	Chiseling compacted subsoils not only serves to increase binding with respread topsoil but also allows for plant root development and penetration that may otherwise be restricted.
Spreading Stockpiled Topsoil	Surface treatments to reduce topsoil erosion	Loss of topsoil and seeds due to water and wind erosion.	Same as above	Mulching recontoured topsoil with different types of wood fiber to retard erosion, slow evaporation, and increase rain-water infiltration. <u>Cost:</u>	Coal Mining, Shirley Basin, Wyoming	Schuman et al. 1980	Effective mulching must be uniformly applied over a continuous area since exposed materials are a source of soil & water transport and wind may undercut adjacent mulched areas rendering the treatment useless (Hodder 1975). Organic mulches require nitrogen fertilization to compensate for denitrification during decomposition (Kay 1978). Large chunk mulches such as shredded bark (Aldon et al. 1975) and redwood litter (Singer and Blackard 1978) may reduce runoff but also reduce herbage production by interfering with seedling emergence (Aldon et al. 1975). Straw and hay mulches are used commonly in the west (Kay 1978) but Schuman et al. (1980) found that small grain (barley) stubble seed in the spring with fall grass seeding was superior to crimped barley straw mulching in reducing wind erosion and was less expensive than crimped straw.
				Application of soil stabilizing chemicals in concert with wood fiber mulching. <u>Cost:</u>	Disturbed slopes	Verma and Thames 1978	Because of expense, soil binders are recommended only for steep slopes and problem areas (Verma and Thames 1978). Various combinations of mulches and binders have provided positive erosion control treatments: straw tacked with Curasol AH (Plass 1973; virgin wood fiber with Ecology Control M-Binder (Kay 1978). Straw mulch tacked with asphalt emulsion (Packer and Aldon 1978); straw mulch bound with woodfiber (Wright et al. 1978) are some examples.
				Use jute, cotton, and paper netting or fiber glass matting for temporary erosion control on steep slopes. <u>Cost:</u>	Road corridor excavations	Kay 1978	Matting and netting is also expensive. These need to be fastened to the soil with staples but erosion beneath these materials is common (Kay 1978).
				Use of submerged burlap strips set in soils at perpendicular angles to direction of runoff. <u>Cost:</u>	Same as above	Heede 1975	Submerged burlap strips decreased soil loss by 14 times compared to control sites. Burlap lasted for 5 to 6 years during which a perennial plant cover became established in 2 to 3 years.
				Roughened cloddy surfaces to increase infiltration and decrease erosion. <u>Cost:</u>	Field experiments	Johnson et al. 1979	Field experiments indicate that a roughened surface decreased soil erosion by 89% and runoff by 77% based on smooth surface measures.

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Spreading Stockpiled Topsoil (cont'd)				Construction of snowfencing or vegetation windbreaks to retard erosion and increase water availability. <u>Cost:</u>	Coal Mining, Lincoln County, Wyoming	May et al. 1971	Abundant grass seedlings on plots behind snow fences compared to control plots not affected by snow fencing were a result of the additional moisture in snow accumulation.
Revegetation	Establishment of a temporary ground cover	Loss of topsoil due to wind and water erosion.	Same as above	Use of stubble mulching to establish a pioneer crop. <u>Cost:</u>	Coal Mining, Shirley Basin, Wyoming	Schuman et al. 1980	Seedling establishment (from a mixture thickspike wheatgrass, green needlegrass slender wheatgrass, and western wheatgrass) was higher for barley stubble treatments than for crimped straw mulch. Barley stubble produced less soil temperature fluctuations and greater soil water infiltration than crimped straw.
				Planting crested wheatgrass where topsoil thickness is less than 8 in. <u>Cost:</u>	Coal Mining, North Dakota	Power et al. 1979	Where no topsoil was placed over sodic mine spoils, crested wheatgrass produced over 100% grain yields, compared yields of spring wheat, alfalfa, or native grass mixtures (Power et al. 1980, in Schuman and Power 1980). However, wildlife species diversity in crested wheatgrass stands has been shown to be significantly lower than on adjacent sagebrush habitats (Reynolds and Trost 1979).
				Contour furrowing followed by drill seeding western wheatgrass and Russian wildrye. <u>Cost:</u>	Coal Mining, Northeast New Mexico	Aldon et al. 1980	Two cool-season species, western wheatgrass and Russian wildrye, became well established on respread topsoil after two growing seasons. Optimal ground preparation and seeding methods were contour furrowing, seed drilling, followed by straw mulching.
				Establishment of grasses and clover on different soils and precipitation regimes. <u>Cost:</u>	Pipeline corridor, Washington	Ellis 1982	Where cover establishment of exotic grasses and legumes is emphasized, recommended mixtures of Tall fescue, white clover, subterranean clover, have been suggested for use on soils with a high coarse-fragment content and drought conditions. However, no information was provided on the success of these mixtures in erosion control and nutrient fixing for future establishment of native species.
				Use western wheatgrass transplants to establish vegetative cover on raw spoils under drought conditions. <u>Cost:</u>	Coal Mining, New Mexico	Aldon et al. 1973; Cable 1977	Both studies show that western wheatgrass plug transplants grown for 6 weeks to 3 months produced new shoots and rhizomes under poor soil and precipitation conditions.

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Revegetation (cont'd)				Use of legumes to stabilize and enrich spoils or spoils covered with topsoil. <u>Cost:</u>	Coal Mining, Colorado	Nicholas McGinnies 1982	Alfalfa and cicer milkvetch both produce good root mass and above ground herbage when grown on bare spoils. Productivity of the two legumes was better than for any of the grasses tested and may be used to develop root systems and fix nitrogen on either topsoil or bare spoil surfaces.
	Establishment of native plant species	Wildlife habitat lost during development and surface disturbances may be ameliorated by revegetating site with a variety of native plant species, the choice of which is dependent on species tolerances, site characteristics, and land use (wildlife management) goals. Homogenous stands of introduced plant species have been shown to provide very limited habitat for wildlife (e.g. Reynolds and Trost 1979).	Reynolds and Trost 1979; also see Off Site Habitat Improvements: General Wildlife Habitat, Well Site Selection, above	Use freshly stripped topsoil as a seed source for native plant species. <u>Cost:</u>	Coal Mining, North Dakota	Iverson and Wali 1981	Although freshly stripped topsoil has served as a seed source for perennial grasses and forbs, woody shrubs and annuals, stockpiled topsoil commonly produces few native species and secondary successional species such as Russian thistle, fox-tail barley halogeton and cheatgrass brome are likely to become established.
				Tayloring seed mixtures to wetlands, lowland drainages, uplands and conifer zones with various proportions of perennial cool-season native grasses. Use of a supplemental seed mixture consisting of native warm-season grasses, forbs and shrubs. <u>Cost:</u>	Coal Mining, Montana	Coenenberg 1982	Reestablishment of native species is a two phase process: Phase I; warm-season grass/forb/shrub seed mixtures are seeded on a chisel plowed seedbed fertilized with phosphorous and finally mulched with native grass hay; Phase II begins one to two growing seasons after Phase I with drill seeding cool-season grass mixtures appropriate to the site. Nitrogen fertilizer and sprinkler irrigation is used following the first phase and seeding periods are before early spring or fall rains for both phases. Shrubs and trees are planted from greenhouse propagations.
				Employ temporary irrigation measure to facilitate establishment of native plant species. <u>Cost:</u>	Coal Mining, Montana	Young 1982	Biomass and species composition of seeding mixtures of perennial cool and warm season grasses, annual grasses, forbs, and shrubs were highest for spring seedings and 3 months of irrigation (sprinkler irrigation heads). However, species diversity, after three growing seasons, declined on plots subjected to 3 months of irrigation. One month of temporary irrigation was determined to provide the most cost efficient technique with the best long term results.

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Revegetation	Establishment of wildlife forage and cover plant species	Wildlife forage and cover lost during surface disturbance may be mitigated by revegetating sites with specific plant species, primarily shrubs.	See comments, below	Seeding, transplanting bare root and container grown shrubs, mature plant transplants, root/rhizome sprigging and sodding/root pad transplantation for shrub establishment. <u>Cost:</u> Seeding and bare root plantings of fourwing saltbush. <u>Cost:</u> Transplanting container grown rubber rabbitbrush, shadscale saltbush, fourwing saltbush, and true mountain mahogany. <u>Cost:</u> Drill seeding bitterbrush. <u>Cost:</u> Growth of greasewood and fourwing saltbush in containers enhances survival when transplanted in arid areas. <u>Cost:</u> Different shrubs propagated in containers survive better on south than on north facing slopes. These include big sagebrush, antelope bitterbrush, rubber rabbitbrush and Woods rose. <u>Cost:</u>	Coal Mining, New Mexico Same as above Range Improvement, California Range Improvement, Utah Road Corridor Reclamation, Northwest Nevada	Aldon 1981 Aldon and Pase 1981 Hubbard and Sanderson 1961 Barker and McKell 1979 Everett 1980	The following provide reviews of practices for establishing shrubs: Holmgren and Basile 1959, Plummer et al. 1968, USDA Forest Service 1979, Croft and Parkin 1979, Van Epps and McKell 1980, Monsen and Plummer 1978, USDA, Forest Service 1982c. Drip irrigated plantings of 3 month old plantings of fourwing saltbush had higher survival and plant height after 5 years on protected plots than directly seeded saltbush. Plant spacing is important. Establishment of transplanted shrubs is increased if root depth is increased if root depth is sufficient to survive drought conditions. Rubber rabbitbrush and fourwing saltbush had the best survival rate after 6 years in fenced plots. On dry sites, fall seedings of bitterbrush had highest success since soil moisture during spring germination was sufficient. The results of this study show plants grown in tall containers establish a long root system that, following deep planting, should enhance drought resistance. Total shrub cover for shrub species tested was greater on south than north slopes. Mountain snowberry and common bladdersenna were exception. Shrub transplant mortality on north slopes appeared to be related to rill erosion and soil sloughing and the overall harsher microenvironment on this aspect.

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Revegetation (cont'd)	Establishment of wildlife forage and cover plant species (cont'd)			Produce cuttings of big sagebrush and Wyoming sagebrush as transplant sources. <u>Cost:</u> Shrub browse species may be established by seeding and planting bare-root and containerized stock. <u>Cost:</u> Use bitterbrush seeds from local seed sources to establish a transplant stock or for seeding. <u>Cost:</u> Vegetatively propagate aspen from clones having most desirable characteristics. <u>Cost:</u>	Range Improvement, Utah Range Improvement, Black Hills, South Dakota Range Improvement, Idaho Aspen Rehabilitation, Rocky Mountain Area	Alvarez-Cordero and McKell 1979 Dietz et al. 1980 Medin and Ferguson 1980 Schlier 1978	The authors cite 3 factors leading to successful propagation: treatment with synthetic growth auxin (IBA), collection of winter cuttings, and between plant differences in rootability. Hand seeding true mountain mahogany and antelope bitterbrush demonstrated promise after ten years. Common chokecherry was best established from bare root stock as well as silverberry and buffalo berry. Generally, plantings of bare root stock produced the best results. Planting sites were scalped to reduce competing vegetation. Seeded bitterbrush from local sources had better survival than transplants while wedgeleaf ceanothus survived better from transplanted stock. Aspen suckering and rooting ability shows clonal variation and success of propagation depends, in part, on selection of clones with the best characteristics. Roots are best collected for sucker propagation in the spring, are treated with fungicide, ends sealed with paraffin before planting in vermiculite. Synthetic auxin treatment (IBA) is also used.
	Landscape design to enhance shrub establishment			Plant shrubs in concave rather than convex land surfaces. <u>Cost:</u>	Coal Mining, North Dakota	Wollenhaupt and Richardson 1982	Establishment of hardwood shrubs is largely dependent on soil moisture and woody draws are created by concave and convergent landscape forms. Orphan spoils observations substantiate woody community succession as a function of topographic concentration of moisture.

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PHASE II STUDY SELECTION PROCESS

At the end of Phase I, the complete report containing the individual Task 1, 2, 3, and 5 reports was submitted to representatives of the PCC for their critical review. Representatives then met in Laramie with the contractors and the contract administrator to allow the PCC to comment upon the report, question its content, and suggest revisions. At this meeting, one day was set aside to discuss requirements for additional work in the Overthrust Belt and to identify Phase II studies.

The contractors and PCC representatives developed a list of studies based on the information contained in the report, established a set of criteria for use in ranking suggested studies, and then selected a subset from that list which, by virtue of their performance against the criteria, are to be carried forth into Phase II.

Twenty-one studies were included in the initial list. In general, these studies are designed to either fill local data gaps, assess the reality of impacts of development and disturbance on wildlife and their terrestrial and aquatic habitats, or determine the effectiveness of impact mitigation strategies.

Seven evaluation criteria were used to rank these 21 studies and select those for Phase II consideration. These criteria were:

1. Broad Applicability. All other factors being equal, studies which offer the benefits of results that apply both within the study area and to adjacent areas into which oil and gas development would expand would be rated more highly than those that lack such applicability. Likewise, studies which would provide information useable for several species are more broadly applicable than those which provide information useable for a single species;
2. Relevance to PCC Objectives. Each agency initiated its participation as a member of the PCC with certain objectives in mind. Studies which could meet these objectives received high priority;
3. Cost-Effectiveness. Return per unit investment was assessed in terms of the value of the acquired information given the potential expenditure for the study. Those studies which were more cost-effective than others received higher rankings;
4. Relevance to Species of Management Interest. Studies focusing on species of management interest would rank higher than those that do not;

5. Compatibility with Other Research. Research currently underway under other authority, including some by PCC agencies, covers some of the research topics in the list of 21. Studies that do not overlap these or which complement them are rated more highly than those which essentially would be duplicative;
6. Likelihood of Meeting Study Objectives. Studies which, by virtue of their complexity, lack of suitable study areas, or difficulty due to rigorous experimental design, are not likely to succeed in attaining their objectives are considered acceptable candidates for funding;
7. Immediacy of Results. Phase II was originally designed to span a two-year period. Studies need not be completed within that two-year period and full recognition is given to the need to allow studies to run their effective required lengths. However, other variables being equal, a study which can yield immediate results and be applied to the study area more quickly than others is rated higher.

These criteria operate as a set without undue emphasis or priority placed on one over another. In other words, broad applicability was given no more consideration than immediacy of results. However, a study rated extremely highly by the PCC on the basis of a single criterion was considered a candidate study regardless of its performance with respect to other criteria.

This list of 21 candidate studies was compressed during the evaluation. Several studies were combined under the recognition that they were very similar and/or could be accomplished together more effectively than they could separately. Other studies were dropped from consideration because they would duplicate work being conducted elsewhere or possessed a more national than local character and value.

RECOMMENDED PHASE II STUDIES

From among the 21 studies discussed above, four are recommended for Phase II consideration. These include a case study of the effectiveness of reclamation practices, improvement of the Task 5 mitigation tables, an analysis of sediment production on disturbed lands and methods available for control, and a study of habitat distribution. The background behind each of these studies, their objectives, and the methods to be used and products desired for each of these studies is described below.

Study One: Analysis of Success and Cost-Effectiveness of Current Reclamation Practices

Background. A variety of reclamation practices have been used by mining and oil and gas companies in the Overthrust Belt and the surrounding area. Some companies have followed agency specifications; others have

initiated in-house efforts at developing innovative alternative techniques. Agencies such as the BLM have also developed and tested new or alternative techniques. These techniques have not been equally costly or equally successful. Research into the success and cost-effectiveness of reclamation techniques has also been undertaken by member companies in the Overthrust Industrial Association, land management agencies, and other organizations such as the American Petroleum Institute, Wyoming Mining Association and the Northwest Colorado Wildlife Consortium.

One of the primary objectives of the Cooperative Wildlife Program is a list of workable mitigation alternatives, including reclamation practices. A limited investigation into current practices was made in Phase I of the Cooperative Wildlife Study. This study would be designed to complete the investigation.

Objectives. The objectives of this study are to:

1. Determine from agency and accessible company records the costs of reclamation techniques (e.g., landform reclamation, topsoil stockpiling, erosion control, seedbed preparation and protection, spoil treatment and application of growth amendments, weed control) tested and used both in the Overthrust Belt and adjacent areas with similar climatic and physical conditions;
2. Determine objectives and, accounting for site and contractor variation, compare results with stated objectives for a series of sample (case study) reclamation efforts on road and pipeline corridors and well pad sites;
3. Evaluate techniques or combinations of techniques in terms of their effectiveness in meeting stated objectives;
4. Compare techniques or combinations of techniques in terms of their relative cost-effectiveness and, where possible, identify those that are most cost-effective; and
5. Recommend for testing those techniques found to show promise for cost-effectively accomplishing reclamation.

Methods. Cost information should be obtained through company input and by inspecting agency records. In addition to cost information, opinions as to the reasons for the range should be solicited. For specific cases where the objective of the reclamation effort has been or can be established after the fact, results should be compared with objectives. Objectives may be stated as agency or landowner stipulations. They may, for example, require slope and soil stabilization, revegetation to a specified cover level or species composition within a specified period, or return to

pre-disturbance wildlife use, but may be stated either qualitatively or quantitatively. Restatement in terms that allow field measurement will be necessary in some cases to assess success.

Assessments of success and cost-effectiveness may not exist in reclamation records or no monitoring may have been done. Field tests will be necessary to assess past efforts in some cases. Additional field tests should be done at sites for which reclamation is planned during the study period to evaluate types of techniques for which assessments do not exist and cannot be inferred from site visits. These tests should complement those done by industry and agencies if the techniques involved warrant consideration because of their potential.

The specific methods used to assess cost-effectiveness are left to the contractor but, at the minimum, should be semi-quantitative and allow determination as to whether or not the reclamation effort met threshold requirements or objectives. Cost comparisons should be made among those that meet objectives and the most cost-effective technique or combination of techniques should be identified. Explanations for variation (i.e., physical setting, site-specific conditions, contractor competence) in costs between techniques should accompany the analysis and ways to improve cost-effectiveness should be offered where possible.

Product. The product should be a report that accomplishes the objectives stated above and: 1) identifies those techniques which can be used in the Overthrust Belt to cost-effectively reclaim areas disturbed by oil and gas and related industrial development; 2) identifies those techniques which are most cost-effective under specified site conditions; and 3) points out those techniques which show promise but have not been tried by OIA companies or in the Overthrust Belt.

The results of the study should be submitted to company and agency personnel prior to preparation of the draft submitted to the OIA. The final report should be well organized and clearly written. Papers publishable in professional technical journals should result.

Study Two: Improvement of Mitigation Tables (Task 5)

Background. The mitigation tables in Task 5 were intended to synthesize what is known about techniques to mitigate impacts on wildlife from oil and gas development both in and outside of the Overthrust Belt. The tables contain measures used or identified by management agencies and others to mitigate impacts known from observation of practices in the Bear River Divide and elsewhere and impacts reported or inferred in the literature. As noted in the tables, many of the mitigative alternatives have either never been applied, or if they have, were not evaluated as to their effectiveness,

benefits to wildlife, or their costs. Also, many states with active mitigative requirements did not adequately respond to requests for information made during Phase I. Thus, data gaps still exist in planning mitigation, and it is worthwhile to expand the tables in Phase II activities.

Objectives. In Phase II, work on the tables should continue as follows: 1) fill in data gaps within the tables; 2) provide a quantitative analysis of costs of various alternatives, perhaps noting which costs can be partially borne by management agencies through planning for common goals such as habitat improvement or off-site mitigation; 3) determine how to maximize the utility of the tables and facilitate updating; and 4) add new information to the tables which has been made available since Fall 1982.

Methods. Methods which might be used include a more personal communication with state agencies and oil and gas representatives in several states. In Phase I, states were contacted by multiple mail surveys, but several provided no response. Perhaps a more extensive telephone survey requesting literature in combination with personal interviews may be needed. To determine costs of various alternatives, perhaps several economic techniques can be used which standardize actual and contributed costs of application, both in the short- and long-run. Meetings should be held with engineers and others that use the techniques, to determine cost range. Costs should at least be subjectively compared to benefits to wildlife, such as: "For a cost of \$1,000, X numbers of Y wildlife species can be saved by rerouting a road." There will undoubtedly be great difficulty in surveying costs in such a fashion that results are readily interpretable, dependable, and unbiased in terms of benefits to wildlife.

To facilitate updating, a contractor may suggest a loose-leaf binding or other simplified means of entering new data. The contractor should attempt to organize the results in an easily referenced, publishable form which could be used by agency officials in dealing with field operators.

Products. In Phase II the tables should be enhanced with significant new documentation of mitigative alternatives and costs for many or most recommendations. The tables should also include new data, perhaps some from Phase II field studies, as to the benefits to wildlife of applying various alternatives. The results should also suggest further gaps and field projects which need to be evaluated in the future and in other areas. A published product should result.

Study Three: Quantity and Control of Sediment Transported From Disturbed Lands

Background. Normal erosional processes and historic land use practices have contributed to sediment to streams and drainage systems in the Overthrust Belt. Development has created further surface disturbance and added to sediment volumes transported into streams under "natural"

conditions, but the relative contribution associated with development has not been quantified, and the influence of mitigation alternatives on sediment transport is not known.

Objectives. This study would have three primary objectives. These are to:

1. Determine the amount of sediment transport from areas not experiencing development;
2. Determine the amount of sediment transport associated with specific development activities (access roads, drill pads, pipelines, etc.); and
3. Determine the quantitative influence of high-potential mitigation alternatives on sediment transport.

Methods. Methods available for assessing sediment transport from the land include: 1) modeling watershed using soil and precipitation data in conjunction with sediment transport equations, 2) standard field assessments of erosion and projection of soil loss, 3) evaluation of sediment accumulation in sediment traps, and 4) measurement of soil transport from specific areas using run-off and suspended solids data. Measurement of soil transport provides an index of the amount of sediment that may be deposited downstream. It can be determined by construction of weirs with automatic water samples. The approach offers a direct means of assessing sediment transport from small, generally first-order watersheds under varying degrees and types of disturbance, as well as B-14 high-potential mitigation measures. Mitigation alternatives could include disturbance location away from the receiving stream, slope of disturbed surface, revegetation of disturbed surface, or the type and extent of constructed sediment traps.

Product. The work should yield quantitative information on the extent of sediment transport and the influence of 3-4 specific mitigation alternatives. The product should enable planners, engineers, and biologists to assess the possible impact of development on a site and the type and extent of mitigation measures to keep sediment transport at or near pre-development levels.

Study Four: Habitat in the Overthrust Belt

Background. Habitat loss or alterations is unavoidable with any development. However, certain types of habitat are especially valuable (such as riparian areas) to fish and wildlife. Once the distribution of habitat types and their quality are known, distribution of a number of wildlife species can be quickly assessed. There is a need, therefore, to determine the quantity and quality of habitat occurring in areas of the Overthrust Belt, especially those habitats that are highly important to fish and wildlife.

Objectives. The objectives of this study are to:

1. Determine, through consideration with state wildlife agencies, the amount and value of fish and wildlife habitat in portions of the Overthrust Belt with emphasis on habitat supporting native species and those of high management interests;
2. Construct habitat maps identifying the distribution and quality of fish and wildlife habitats in those areas defined in point number one;
3. Develop distribution maps as overlays showing distributional patterns by seasons for wildlife species of high management interests;
4. Indicate species associated with each of the key habitat areas; and
5. Indicate habitat requirements associated with habitat types of selected wildlife species.

Methods. The amount of fish and wildlife habitat in study areas should be determined using current maps, aerial photos, as well as site-specific information. Fishery habitat quality can be quantified for streams using methods appropriate to state agencies. Wildlife habitat quality can be quantified utilizing data from the literature and in some cases data collected in the field indicating wildlife use of the area. Selected field sampling techniques will assist in determining the prime area of habitats that are utilized by wildlife. The location and quantity of specific habitat types will be mapped on USGS 7-1/2 minute topographic quadrangles. The value of the habitat types to selected species will be presented in a chart format with descriptions of the need at various stages of the life cycles.

These data should be coordinated closely with the type of distributional data and habitat data of Game and Fish Departments. The first step in developing this product should be to contact the specific agencies and determine the area to be surveyed and the type of information they have available. Once these data are assimilated, they can be utilized to prepare habitat and wildlife distribution maps for the area. Other federal and private agencies should be contacted to determine what type of information they have or are currently working on in the area. These data should all be assimilated so a comprehensive habitat map can be utilized by all agencies.

Product. The products will include documentation of procedures, tabular material on fish and wildlife habitat quality in the surveyed areas, maps of the location of specific habitat types, and charts describing the importance of specific habitat type for selected species. Key species of wildlife distribution patterns will be shown as well as distributional or habitat needs of species of high management interests. These data can then be made available to corporate and private management agencies for use in joint planning efforts.

RECOMMENDED PHASE II STUDIES

INTRODUCTION

The Overthrust Industrial Association (OIA) is currently carrying out its Cooperative Wildlife Program, which consists of three elements. These are law enforcement assistance, an environmental awareness training program, and a wildlife management study. This report summarizes the technical information developed in Phase I and outlines a program of proposed research for Phase II based on Phase I.

The goals and work programs carried out in the Cooperative Wildlife Study were defined and prescribed by the Project Coordinating Committee (PCC), a management group comprised of representatives from wildlife and land management agencies, private wildlife interests, and industry. A five-county area centered on the Bear River Divide, including Uinta and Lincoln Counties in southwestern Wyoming, Rich and Summit Counties in northeastern Utah, and Bear Lake County in southeastern Idaho, is the focal point for the study. This is the current operating area for the OIA.

This report concludes Phase I of the study. In this phase, the authors comprehensively evaluated existing information on wildlife and wildlife-related resources in the study area, critically reviewed literature on the impacts of land use and development on wildlife, assessed mitigation practices related to oil and gas and related development, and evaluated the methods presently used to analyze habitat and predict development impacts.

Phase II will consist of studies designed to complete the base of information available on resources, methods, impacts, and mitigation practices. It Phase III will combine the results of Phases I and II into a management-oriented product that: 1) can support predictions of the impact of oil and gas and related development; 2) identifies potentially sensitive areas within the five-county area; and 3) provides a list of workable, cost-effective mitigation measures.

PHASE I OF THE STUDY

Phase I was divided into six tasks. This report is the product of Task 6. The first five tasks and their specific purposes were:

Task 1. Assess analytical and predictive procedures for identifying environmentally sensitive areas and evaluating impacts. These included methods for defining issues, managing data, evaluating wildlife habitat, and predicting impacts.

Task 2. Comprehensively review the published North American literature regarding effects of resource development on wildlife resources.

Task 3. Identify and review unpublished literature and related data available from agencies, private individuals, industrial operators, and universities concerning wildlife resources within the study area.

Task 4. Conduct three workshops to solicit public concerns and to present the finding of this study to the representatives of the PCC.

Task 5. Review the literature on mitigation practices currently applied to oil and gas development both within and outside of the study area.

PHASE I FINDINGS

Individual reports were produced for Tasks 1, 2, 3, 4, and 5, each presenting the task findings. This section briefly summarizes the findings of each report and provides the background information for the recommendations made for Phase II work.

Task 1

The analytic and predictive procedures reviewed in Task 1 were grouped into four categories: collaborative analysis methods, geographic information systems applications, habitat and environmental assessment methods, and population simulation models. These categories were not mutually exclusive. For example, a collaborative analysis method may also be usable to evaluate habitat or assess impacts, as was actually found to be the case. The categories were used as an organizational framework within which to conduct meaningful evaluations and comparisons between methods.

Methods were evaluated in terms of several criteria. Among these were utility in identifying environmentally sensitive areas, in assessing impacts, and in assisting managers develop mitigation programs. These three criteria were outlined by the PCC at the outset of the project. A broader multi-step planning process that included these three steps as well as a description and assessment of area-wide resources, evaluation of development alternatives and management strategies, monitoring, and reevaluation of development and management scenarios also was used. For each category, additional criteria were added to account for applicability to the study area, difficulty and costs of application, etc.

Collaborative Analysis Methods. The collaborative analysis methods evaluated included the Delphi Method, Nominal Group Technique (NGT), PUBLIC, and Adaptive Environmental Assessment and Management (AEAM). All four methods are designed to bring individuals and organizations "together" to jointly identify and solve management and planning problems. Corollary applications include issue identification, problem definition, conflict resolution, and, to a limited extent, public involvement.

The Delphi Method and NGT have been most widely applied in business and industrial operations settings. Both are primarily intended to facilitate group analyses and decisions by using devices that control dominating person-

alities, authority figures, and hostile or argumentative individuals. PUBLIC was designed primarily as a device for incorporating public input into the natural resource management process. It can be used to determine the extent to which various interests agree or disagree on management goals and strategies and to allow an agency to accommodate the political setting in its planning practice. AEAM uses one or more workshops attended by key scientists, managers, decision-makers, and other stakeholders to develop a computer model of a natural system which contains sensitive resources whose management or modification through development has stimulated controversy and conflict. The product is a computer simulation model used to test an array of development and/or management scenarios so that the group can jointly decide on an acceptable course of action.

All four methods can be used successfully as collaborative analysis tools. Compared with AEAM, the Delphi Method, NGT, and PUBLIC are relatively inexpensive and easy to apply. At least initially, AEAM requires the assistance of outside experts familiar with running workshops, getting people to collaborate, and developing smoothly-running computer simulation models. Its computer capabilities lend no advantage in the area of collaborative analysis, but AEAM can be applied more effectively than the other three methods throughout the multi-step planning process outlined above. Therefore, it was considered superior.

Geographic Information Systems. Geographic information systems (GIS) are manual or computerized systems used for storing, analyzing, and displaying information in the forms of maps, reports, aerial photographs, etc. Computerized systems, which were reviewed in Task 1, require computer facilities and operating staff and are initially much more costly to develop than manual systems. But under heavy use, they offer considerable advantages which can make the initial investment worthwhile.

Assuming conditions would warrant its use, several feasible ways exist for employing a computerized GIS. These include: 1) contracting an outside consultant to gather the information from the three states' agencies, computerize the data base, and conduct analyses for the PCC or individual agencies as necessary over some specified contract period; 2) using either of the two operation systems available among the PCC agencies, specifically the State of Utah's system or the Wyoming BLM's system; or 3) using one of the systems available through another public institution or agency. The USFWS operates a pair of systems, either of which can support its Rapid Assessment Methods (RAM).

Each alternative can be used to conduct analyses and produce results useful in identifying environmentally sensitive areas, describing full area-wide resources in either map or textual form, evaluating alternative development scenarios (road locations, stream crossings, rail alignments, sour gas plant sites, man camp sites, etc.) and management (mitigative) actions, and in assessing graphically in a quantitative fashion the impacts of development. Some differences distinguish the alternatives, but these relate primarily to the administrative details of implementing GIS applications across state and

jurisdictional boundaries. Although these differences would be significant at a time when a choice between the alternatives became necessary, the use of a computerized GIS and exploration of the administrative implementation mechanisms are relatively secondary in importance compared with the more immediate needs of completing resource data bases and assessing the impacts of existing development and the success of existing mitigation and reclamation programs.

Habitat Evaluation Methods. The habitat and environmental assessment methods evaluated include terrestrial and aquatic methods. The terrestrial methods include the U. S. Fish and Wildlife Service's Habitat Evaluation Procedures (HEP), the Wildlife Management Information System (WILDMIS) developed at the Colorado Cooperative Wildlife Research Unit, and Wildlife and Fish Habitat Relationships (WFHR) being developed by the U. S. Forest Service. The aquatic methods include the Physical Habitat Simulation System (PHABSIM) developed by the U. S. Fish and Wildlife Service, Habitat Quality Index (HQI) developed by the Wyoming Game and Fish Department, and the General Aquatic Wildlife System (GAWS) developed by the U. S. Forest Service.

Terrestrial Methods. HEP was developed as a tool for assessing the value of an area to a species, or group of species called a guild, by subjectively rating each areal segment of habitat according to a model called a Habitat Suitability Index. The index relates existing conditions to optimal conditions for the species or guild. The product is an estimate of "habitat units", a number which can be used to compare different areas or the same area at different times, such as before and after development. WILDMIS was developed to set species production (management) objectives, evaluate habitats, assess impacts, and identify the most cost-effective management strategy. WILDMIS contains several components, the central one being PATREC. PATREC is a habitat evaluation method that employs pattern recognition and conditional probabilities to calculate the probability that an area is high- or low-quality habitat for a particular species. The product is a crude estimate of long-term mean population density for the area evaluated. WFHR is a large data base that contains regional information on terrestrial and aquatic vertebrate species and their habitats. WFHR is used in multi-resource management to characterize habitat quality, evaluate timber management alternatives, predict harvest impacts, and to develop mitigation programs. The WFHR data base has been computerized by the Intermountain Region (Region IV).

HEP and PATREC are general methods that could be applied easily to the Overthrust Belt. WFHR would be less applicable because the data base is forest-oriented and little forest exists in the Overthrust Belt. Although HEP and PATREC would be excellent for large-area habitat evaluation, none of the three methods would be a particularly good tool for identifying environmentally sensitive areas, predicting impacts, or evaluating reclamation or mitigation practices. They have not been rigorously field tested or evaluated and do not have particularly strong histories of successful application. Applications also require considerable commitments of time and manpower.

Aquatic Methods. PHABSIM was developed to simulate and quantify: 1) available microhabitat for fish species or life phases of interest under dif-

fering flow regimes; 2) water quality conditions; and 3) physical channel structures. Field measurements, computerized hydraulic simulation, and habitat suitability rating curves are used to produce estimates of weighted usable area of instream habitat over the range of stream discharges considered. HQI was developed to evaluate aquatic habitat but has been used to assess habitat improvement potential, predict standing crops, and support instream flow recommendations for salmonid species. HQI incorporates field data into one of two computerized multiple regression models. GAWS is a computerized system developed to inventory, describe, monitor, and predict habitat conditions and habitat vulnerability to land use impacts. It includes methods for conducting macroinvertebrate surveys, instream flow analyses, four levels of stream surveys; lake surveys will be added later when they become operational.

All three aquatic habitat evaluation methods are suited for application to the Overthrust Belt. PHABSIM permits better species- and lifestage-specific analyses than HQI and GAWS. Documentation is more accessible for PHABSIM and HQI than for GAWS. GAWS and PHABSIM, however, seem to be more broadly applicable than HQI. HQI yields standing crop as the application product; PHABSIM and GAWS yield unitless quality indices. HQI provides a more clearly usable end product. Programs necessary to run HQI on a small programmable calculator have been developed and are available; GAWS and PHABSIM require out-of-office analyses. HQI appears, therefore, to be the superior aquatic habitat evaluation method.

Population Simulation Models. Three population simulation models were evaluated: ONEPOP, POP50, and POSIM. Each is designed to mathematically represent wildlife population dynamics in a model typically run on a computer. All use population size, age, and sex information. ONEPOP was developed by the Colorado Cooperative Wildlife Research Unit, is written in Fortran IV, and is used in batch mode on large computers. POP50 was developed privately as an alternative to ONEPOP and was designed for use on microcomputers. POSIM was developed by the Montana Department of Fish and Game and is written in Gasp IV. All can be used to model population dynamics for species with one birth pulse annually. ONEPOP and POP50 would apply well to the Overthrust Belt but all three methods offer little utility in identifying environmentally sensitive areas, assessing impacts, or developing mitigation programs because they were not designed for these purposes. ONEPOP and POP50 have poor histories of application and POSIM's history is unknown. ONEPOP is the most accessible model and POSIM is most demanding in terms of time and manpower requirements.

Task 2. Task 2 was a review of the available literature on fish and wildlife impacts resulting from natural resource development and human activities. While the primary focus of the review was to examine documented relationships between petroleum industry development and wildlife, reported influences of road construction and use, mining, logging, aircraft, transmission lines and other structures, grazing, fire, and recreational use in wildlife habitats were included. These activities have similar effects in some respects. Effects on big game, furbearers, raptors, game birds, nongame wildlife, amphibians and reptiles, fish (and aquatic resources), and threatened and endangered species were discussed separately.

The literature search produced very little data on wildlife in the Overthrust Belt prior to oil and gas exploration. In its absence, data collected during the development received primary attention. The major conclusions are:

1. Little research has been done specifically on the impacts of the oil and gas industry on fish and wildlife species occurring in the Overthrust Belt when compared to other forms of development or the environmental alterations associated with logging, road construction, mining, etc. However, available literature suggests that many aspects of oil and gas development are not unique in their impacts on wildlife. Habitat alteration and human disturbance to wildlife during oil and gas development occur in much the same manner as other forms of development. Information gained from impact research on logging, grazing, fire, mining and other forms of habitat alteration is useful. However, habitat use by affected wildlife populations and population response to habitat improvements are poorly understood.
2. In general, little information exists on wildlife species and the possible impact of oil and gas development on wildlife in the Overthrust Belt. Most of the studies have been descriptive rather than experimental and those available lack adequate controls. Most have also been short-term studies. Generally, the studies have lacked testable hypotheses and/or a solid theoretical foundation. Interpretations are also confounded by inadequate sampling techniques and insufficient replication.
3. For big game, little information exists on impacts of oil and gas and related industrial development and activities. Elk movement is known to be affected by seismic activities and bears are known to abandon dens when seismic and/or construction and excavation activities are nearby. Effects of road and air access result primarily when humans leave their vehicles, but depend upon the cover near the roads and vary with species. Specific information on habitats and distribution is needed so that areas that are important, critical, or seasonally sensitive can be identified. Gaps exist in the data on effects on the welfare, survival, and reproductive potential of several species, and the vulnerability by sex and age class is unknown. Increased legal and illegal harvest, displacement and degradation of the habitat into which animals are displaced, and the population effects of displacement are unknown.
4. Except for a study on beaver near Kemmerer, Wyoming, few definitive studies exist on the effects of development on furbearers populations. The literature suggests that some arctic furbearers species are adaptable and tolerate human disturbance, but no data exists on the biology and seasonal sensitivity of species in the Overthrust Belt (wolverine, fisher, lynx, river otter, etc.) that can be used as a basis for accurate impact assessment.
5. Nesting habitat requirements for raptors in the study area are well documented but the effects of development and human activities on

raptor nesting habitat and prey bases are unknown. Population resiliency and the probability of returns to pre-impact levels are also unknown. Raptor management techniques described in the literature would be useful in transmission line support tower design, fenceline placement, and prey habitat manipulation.

6. Information on game bird, nongame, reptile and amphibian, and fish species is also limited. Insufficient information exists for accurate assessments of the effects of development on these species groups.
7. The literature emphasizes the importance of riparian and aquatic habitats in the arid west for many wildlife groups.

Task 3. Task 3 was an evaluation of the utility, or applicability, of local public knowledge of existing wildlife resources in each of the three states in developing baseline descriptions against which the impacts of development and the success of management can be accurately assessed. Raw data, analyzed data, and mapped data were evaluated. The major products of Task 3 are an annotated bibliography, which provides details on all the documents reviewed, and the Task 3 report, which summarizes the findings for the following species groups: big game, game birds, endangered species, furbearers, game fish, raptors, small game mammals, nongame mammals, nongame birds, nongame fish, and reptiles and amphibians. Information on riparian and aquatic habitats also was evaluated.

In Utah, considerable information is available on big game from the Utah Division of Wildlife Resources (UDWR), Utah State University, and the U. S. Forest Service. UDWR information is most extensive and includes harvest reports, which are compiled on a county-wide or herd-unit basis, and habitat distribution maps. Harvest reports and distribution maps contain the primary information available on game birds. The distribution maps, for example, show sage grouse leks, winter range, and breeding range. Bald eagle winter concentration areas and roosts are mapped as are hawk sites for bald eagles and peregrine falcons, but, in general, little information is available for threatened and endangered species. Harvest reports and UDWR maps contain information on furbearers such as otter, marten, and beaver. Habitat maps showing cold- and warm-water fisheries, habitat rankings, and stream classifications exist for the study area and conflicting development and protection needs are identified for game fish. The Randolph Unit Resource Analysis contains nest location and occupancy information for a portion of the study area and UDWR maps show golden eagle, ferruginous hawk, red-tailed hawk, prairie falcon, and great-horned owl nests. Limited data is available for small and nongame mammals and nongame birds and only a single document provides reptile and amphibian data. Nongame fish information is available only as additional data in game fish reports.

In Wyoming, the Wyoming Game and Fish Department (WGFD) prepares annual big game reports for each Data Analysis Unit in the state and the data is broken down by hunt-areas. Big game distribution, habitat use, and population

data are stored in the Wildlife Observation System. For game birds, only sage grouse and waterfowl information is extensive. Annual waterfowl reports are prepared and sage grouse lek, hatching data, brood production, and harvest data are available. The Nature Conservancy's Natural Heritage Program is the best single source of data on threatened and endangered species and the U. S. Fish and Wildlife Service has data on black-footed ferrets, peregrine falcons, and bald eagles. Limited data has been collected on furbearers, this by WGFD and the BLM Rock Springs District. Beaver and beaver pond, mink, muskrat, and skunk data is available as is state-wide information on bobcats. WGFD stream, lake, pond, and reservoir data and BLM stream inventory data contain information on game and nongame fish. The U. S. Fish and Wildlife Service, the BLM, and WGFD have collected raptor data on the study area. Small game mammal information is limited and among the nongame mammals, good information exists only for the prairie dog. Nongame birds have been documented in the study area by state and federal agencies. Reptile and amphibian data is most limited.

Idaho also has better information on big game than it does for most other species groups. The Idaho Department of Fish and Game (IDFG) completes annual big game harvest reports and management plans for mule deer, elk, moose, bear, and cougar. IDFG also prepares annual upland game bird harvest reports but upland game birds receive low management priority in Bear Lake County and information is limited. IDFG and the U. S. Fish and Wildlife Service jointly survey waterfowl in Bear Lake National Wildlife Refuge each summer and fall. State and federal agencies provide information on threatened and endangered species; information is best for the bald eagle. For furbearers, population estimates are available only for beaver; limited data is available for muskrat and qualitative population estimates and rough distribution maps are available for river otter and bobcats. Game fish data come from angler surveys and creel censuses. Surveys exist for the Bear Lake and Bonneville cutthroat trout but limited information is available for other game and nongame fishes. Little information is available for small game and nongame mammals and nongame birds and only habitat matrices exist for reptiles and amphibians.

In general, the data gaps are considerable for all three states and the applicability of most data is limited. The amount and utility of information is generally best but is still incomplete for high-priority species such as big game, threatened and endangered, and game bird species. Information on furbearers, game fish, and raptors is intermediate in amount and quality, and information on other species groups is extremely limited and would be of minimum value for site-specific planning and impact assessment. Often, a higher level of resolution would be necessary to use the data either for site-specific planning or impact assessment. Information on the effects of changing land uses, including the effects of oil and gas and related industrial development, is generally absent.

Task 4. Task 4 provided an opportunity for members of the public to participate in the study and for representatives of the Project Coordinating Committee to review the products produced in the other tasks. Appendix A to

this report contains a summary of the comments made at the public hearing held at the outset of the project. The review comments of the PCC representatives are reflected in the task reports that follow.

Task 5. Task 5 was an assessment of methods used or proposed in a number of states by agencies, consultants, or research personnel to mitigate the effects of development on wildlife. The primary product is a comprehensive table which summarizes the measures taken to mitigate the effects of each of several component activities of oil and gas development. These components include: seismographic testing, exploratory drilling, road development and well site access, increased human activity, field development, and well site and road abandonment. Without judgements as to the reality or significance of impacts, the charts present related mitigation measures, both from oil and gas and other development. Cost data is not readily available from any source. Furthermore, little study accompanied the implementation of the identified measures to determine their effectiveness.

Man camps, seismic explosions, surface-shattering heli-drilling, and helicopter traffic could potentially displace wildlife from nest sites and breeding and feeding areas. Proposed mitigation measures have included restrictions on camp siting, avoidance of critical habitat (calving, lambing, and fawning areas; winter range), and environmental education of field personnel.

Exploratory drilling and well siting could potentially cause direct habitat loss, displacement, and consequent reliance on sub-optimal habitat. Proposed mitigation has included restrictions on length and timing of surface occupancy, confinement of disturbance, establishment of buffers to protect riparian and aquatic habitat, and a host of off-site actions including habitat improvement through prescribed burning, seeding, off-site water development, the construction of artificial nest sites, and animal transplants.

Road and pipeline location and construction practices are believed by management agencies to cause upland and riparian zone erosion, stream sedimentation, and aquatic habitat alteration. Proper culverting, control over stream crossings, buffer zone establishment, and streambank revegetation and stream rehabilitation have been proposed to offset these impacts. Increased traffic and recreational activity potentially disrupt wildlife activities, displace animals, and increase vehicle-related mortality. Road closures, speed restrictions, increased law enforcements, and use of existing roads have been proposed to offset these impacts. Electrical transmission lines can cause raptor electrocution; line location and design modification have been employed to reduce electrocutions.

Reclamation is frequently required of companies as a mitigation practice. Specific practices have included contour (conformity) grading, terracing to control runoff, topsoil stockpiling (with controls on the length of time soil can be stockpiled), deep chiseling to loosen material and improve the potential or successful reestablishment of planted species, a variety of planting schemes involving primarily grasses and forbs but also shrubs, and compaction of fill along pipelines to prevent settlement and subsequent gulley erosion.

Withdrawals from surface and subsurface waters have caused losses in aquatic habitat and upland water sources. The use of deep aquifers not connected to streams or seep springs has been tried as a means of reducing impacts.

In general, a variety of techniques have been tried. Success has not been fully or even adequately evaluated. Cost-effectiveness has not been studied. Also, the information in the tables does not include experience from several oil producing states such as California, Texas, and Louisiana. Mitigation measures taken from the experience in these and other states could be applied to the Overthrust Belt.

PHASE II STUDY SELECTION PROCESS

At the end of Phase I, the complete report containing the individual Task 1, 2, 3, and 5 reports was submitted to representatives of the PCC for their critical review. Representatives then met in Laramie with the contractors and the contract administrator to allow the PCC to comment upon the report, question its content, and suggest revisions. At this meeting, one day was set aside to discuss requirements for additional work in the Overthrust Belt and to identify Phase II studies.

The contractors and PCC representatives developed a list of studies based on the information contained in the report, established a set of criteria for use in ranking suggested studies, and then selected a subset from that list which, by virtue of their performance against the criteria, are to be carried forth into Phase II.

Twenty-one studies were included in the initial list. In general, these studies are designed to either fill local data gaps, assess the reality of impacts of development and disturbance on wildlife and their terrestrial and aquatic habitats, or determine the effectiveness of impact mitigation strategies.

Seven evaluation criteria were used to rank these 21 studies and select those for Phase II consideration. These criteria were:

1. Broad Applicability. All other factors being equal, studies which offer the benefits of results that apply both within the study area and to adjacent areas into which oil and gas development would expand would be rated more highly than those that lack such applicability. Likewise, studies which would provide information useable for several species are more broadly applicable than those which provide information useable for a single species;
2. Relevance to PCC Objectives. Each agency initiated its participation as a member of the PCC with certain objectives in mind. Studies which would meet these objectives received high priority;

3. Cost-Effectiveness. Return per unit investment was assessed in terms of the value of the acquired information given the potential expenditure for the study. Those studies which were more cost-effective than others received higher rankings;
4. Relevance to Species of Management Interest. Studies focusing on species of management interest would rank higher than those that do not;
5. Compatibility with Other Research. Research currently underway under other authority, including some by PCC agencies, covers some of the research topics in the list of 21. Studies that do not overlap these or which complement them are rated more highly than those which would essentially be duplicative;
6. Likelihood of Meeting Study Objectives. Studies which, by virtue of their complexity, lack of suitable study areas, or difficulty due to rigorous experimental design, are not likely to succeed in attaining their objectives are considered acceptable candidates for funding;
7. Immediacy of Results. Phase II was originally designed to span a two-year period. Studies need not be completed within that two-year period and full recognition is given to the need to allow studies to run their effective required lengths. However, other variables being equal, a study which can yield immediate results and be applied to the study area more quickly than others is rated higher.

These criteria operate as a set without undue emphasis or priority placed on one over another. In other words, broad applicability was given no more consideration than immediacy of results. However, a study rated extremely highly by the PCC on the basis of a single criterion was considered a candidate study regardless of its performance with respect to other criteria.

This list of 21 candidate studies was compressed during the evaluation. Several studies were combined under the recognition that they were very similar and/or could be accomplished together more effectively than they could separately. Other studies were dropped from consideration because they would duplicate work being conducted elsewhere or possessed a more national than local character and value.

RECOMMENDED PHASE II STUDIES

From among the list of studies identified above, four are recommended for Phase II consideration. These include a case study of the effectiveness of reclamation practices, improvement of the Task 5 mitigation tables, an analysis of sediment production on disturbed lands and methods available for control, and study of habitat distribution. The background behind each of these studies, their objectives, and the methods to be used and products desired for each of these studies is described below.

Study One: Analysis of Success and Cost-Effectiveness of Current Reclamation Practices

Background. A variety of reclamation practices have been used by mining and oil and gas companies in the Overthrust Belt and the surrounding area. Some companies have followed agency specifications; others have initiated in-house efforts at developing innovative alternative techniques. Agencies such as the BLM have also developed and tested new or alternative techniques. These techniques have not been equally costly or equally successful. Research into the success and cost-effectiveness of reclamation techniques has also been undertaken by member companies in the Overthrust Industrial Association, land management agencies, and other organizations such as the American Petroleum Institute, Wyoming Mining Association and the Northwest Colorado Wildlife Consortium.

One of the primary objectives of the Cooperative Wildlife Program is a list of workable mitigation alternatives, including reclamation practices. A limited investigation into current practices was made in Phase I of the Cooperative Wildlife Study. This study would be designed to complete the investigation.

Objectives. The objectives of this study are to:

1. Determine from agency and accessible company records the costs of reclamation techniques (e.g., landform reclamation, topsoil stockpiling, erosion control, seedbed preparation and protection, spoil treatment and application of growth amendments, weed control) tested and used both in the Overthrust Belt and adjacent areas with similar climatic and physical conditions;
2. Determine objectives and, accounting for site and contractor variation, compare results with stated objectives for a series of sample (case study) reclamation efforts on road and pipeline corridors and well pad sites;
3. Evaluate techniques or combinations of techniques in terms of their effectiveness in meeting stated objectives;
4. Compare techniques or combinations of techniques in terms of their relative cost-effectiveness and, where possible, identify those that are most cost-effective; and
5. Recommend for testing those techniques found to show promise for cost-effectively accomplishing reclamation.

Methods. Cost information should be obtained through company input and by inspecting agency records. In addition to cost information, opinions as to the reasons for the range should be solicited. For specific cases where

the objective of the reclamation effort has been or can be established after the fact, results should be compared with objectives. Objectives may be stated as agency or landowner stipulations. They may, for example, require slope and soil stabilization, revegetation to a specified cover level or species composition within a specified period, or return to pre-disturbance wildlife use, but may be stated either qualitatively or quantitatively. Restatement in terms that allow field measurement will be necessary in some cases to assess success.

Assessments of success and cost-effectiveness may not exist in reclamation records or no monitoring may have been done. Field tests will be necessary to assess past efforts in some cases. Additional field tests should be done at sites for which reclamation is planned during the study period to evaluate types of techniques for which assessments do not exist and cannot be inferred from site visits. These tests should complement those done by industry and agencies if the techniques involved warrant consideration because of their potential.

The specific methods used to assess cost-effectiveness are left to the contractor but, at a minimum, should be semi-quantitative and allow determination as to whether or not the reclamation effort met threshold requirements or objectives. Cost comparisons should be made among those that meet objectives and the most cost-effective technique or combination of techniques should be identified. Explanations for variation (ie., physical setting, site-specific conditions, contractor competence) in costs between techniques should accompany the analysis and ways to improve cost-effectiveness should be offered where possible.

Product. The product should be a report that accomplishes the objectives stated above and: 1) identifies those techniques which can be used in the Overthrust Belt to cost-effectively reclaim areas disturbed by oil and gas and related industrial development; 2) identifies those techniques which are most cost-effective under specified site conditions; and 3) points out those techniques which show promise but have not been tried by OIA companies or in the Overthrust Belt.

The results of the study should be submitted to company and agency personnel prior to preparation of the draft submitted to the OIA. The final report should be well organized and clearly written. Papers publishable in professional technical journals should result.

Study Two: Improvement of Mitigation Tables (Task 5)

Background. The mitigation tables in Task 5 were intended to synthesize what is known about techniques to mitigate impacts on wildlife from oil and gas development both in and outside of the Overthrust Belt. The tables contain measures used or identified by management agencies and others to mitigate impacts known from observation of practices in the Bear River Divide and elsewhere and impacts reported or inferred in the literature. As noted in the

tables, many of the mitigative alternatives have either never been applied, or if they have, were not evaluated as to their effectiveness, benefits to wildlife, or their costs. Also, many states with active mitigative requirements did not adequately respond to requests for information made during Phase I. Thus, data gaps still exist in planning mitigation, and it is worthwhile to expand the tables in Phase II activities.

Objectives. In Phase II, work on the tables should continue as follows: 1) fill in data gaps within the tables; 2) provide a quantitative analysis of costs of various alternatives, perhaps noting which costs can be partially borne by management agencies through planning for common goals such as habitat improvement as off-site mitigation; 3) determine how to maximize the utility of the tables and facilitate updating; and 4) add new information to the tables which has been made available since Fall, 1982.

Methods. Methods which might be used include a more personal communication with state agencies and oil and gas representatives in several states. In Phase I, states were contacted by multiple mail surveys, but several provided no response. Perhaps a more extensive telephone survey requesting literature in combination with personal interviews may be needed. To determine costs of various alternatives, perhaps several economic techniques can be used which standardize actual and contributed costs of application, both in the short- and long-run. To determine cost range, meetings should be held with engineers and others that use the techniques. Costs should at least be subjectively compared to benefits to wildlife, such as: "For a cost of \$1,000, X numbers of Y wildlife species can be saved by re-routing a road." There will undoubtedly be great difficulty in surveying costs in such a fashion that results are readily interpretable, dependable, and unbiased in terms of benefits to wildlife.

To facilitate updating, a contractor may suggest a loose-leaf binding or other simplified means of entering new data. The contractor should attempt to organize the results in an easily referenced, publishable form which could be used by agency officials in dealing with field operators.

Products. In Phase II the tables should be enhanced with significant new documentation of mitigative alternatives and costs for many or most recommendations. The tables should also include new data, perhaps some from Phase II field studies, as to the benefits to wildlife of applying various alternatives. The results should also suggest further gaps and field projects which need to be evaluated in the future and in other areas. A published product should result.

Study Three: Quantity and Control of Sediment Transported From Disturbed Lands

Background. Normal erosional processes and historic land use practices have contributed to sediment to streams and drainage systems in the Overthrust Belt. Development has created further surface disturbance and added to sediment volumes transported into streams under "natural" conditions, but the rel-

ative contribution associated with development has not been quantified, and the influence of mitigation alternatives on sediment transport is not known.

Objectives. This study would have three primary objectives. These are to:

1. Determine the amount of sediment transport from areas not experiencing development;
2. Determine the amount of sediment transport associated with specific development activities (access roads, drill pads, pipe lines, etc.); and
3. Determine the quantitative influence of high-potential mitigation alternatives on sediment transport.

Methods. Methods available for assessing sediment transport from the land include: 1) modeling watersheds using soil and precipitation data in conjunction with sediment transport equations, 2) standard field assessments of erosion and projection of soil loss, 3) evaluation of sediment accumulation in sediment traps, and 4) measurement of soil transport from specific areas using run-off and suspended solids data. Measurement of soil transport provides an index of the amount of sediment that may be deposited downstream. This can be determined by construction of weirs with automatic water samples, an approach that offers a direct means of assessing sediment transport from small, generally first-order watersheds under varying degrees and types of disturbance, as well as B-14 high-potential mitigation measures. Mitigation alternatives could include disturbance location away from the receiving stream, slope of disturbed surface, revegetation of disturbed surface, or the type and extent of constructed sediment traps.

Product. The work should yield quantitative information on the extent of sediment transport and the influence of 3-4 specific mitigation alternatives. The product should enable planners, engineers, and biologists to assess the possible impact of development on a site and the type and extent of mitigation measures to keep sediment transport at or near pre-development levels.

Study Four: Habitat in the Overthrust Belt

Background. Habitat loss or alterations is unavoidable with any development. However, certain types of habitat are especially valuable (such as riparian areas) to fish and wildlife. Once the distribution of habitat types and their quality are known, distribution of a number of wildlife species can be quickly assessed. There is a need, therefore, to determine the quantity and quality of habitat occurring in areas of the Overthrust Belt, especially those habitats that are highly important to fish and wildlife.

Objectives. The objectives of this study are to:

1. Determine, through consultation with state wildlife agencies, the amount and value of fish and wildlife habitat in portions of the Overthrust Belt, with emphasis on habitat supporting native species and those of high management interests;
2. Construct habitat maps identifying the distribution and quality of fish and wildlife habitats in those areas defined in point #1;
3. Develop distribution maps as overlays showing distributional patterns by seasons for wildlife species of high management interests;
4. Indicate species associated with each of the key habitat areas; and
5. Indicate habitat requirements associated with habitat types of selected wildlife species.

Methods. The amount of fish and wildlife habitat in study areas should be determined using current maps, aerial photos, as well as site-specific information. Fishery habitat quality can be quantified for streams using methods appropriate to state agencies. Wildlife habitat quality can be quantified utilizing data from the literature and in some cases data collected in the field indicating wildlife use of the area. Selected field sampling techniques will assist in determining the prime area of habitats that are utilized by wildlife. The location and quantity of specific habitat types will be mapped on USGS 7-1/2 minute topographic quadrangles. The value of the habitat types to selected species will be presented in a chart format with descriptions of the need at various stages of the life cycles.

These data should be coordinated closely with the type of distributional data and habitat data of Game and Fish Departments. The first step in developing this product should be to contact the specific agencies and determine the area to be surveyed and the type of information they have available. Once these data are assimilated, they can be utilized to prepare habitat and wildlife distribution maps for the area. Other federal and private agencies should be contacted to determine what type of information they have or are currently working on in the area. These data should all be assimilated so a comprehensive habitat map can be utilized by all agencies.

Product. The products will include documentation of procedures, tabular material on fish and wildlife habitat quality in the surveyed areas, maps of the location, specific habitat types, and charts describing the importance of specific habitat type for selected species. Key species of wildlife distribution patterns will be shown as well as distributional or habitat needs of species of high management interests. These data can then be made available to corporate and private management agencies for use in joint planning efforts.

APPENDIX A

SUMMARY OF PUBLIC WORKSHOP

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FORMAT AND PROCEDURES FOR THE PUBLIC WORKSHOP

DATE: September 20, 1982

TIME: 7-10 p.m.

PLACE: Sheraton Motor Lodge, Evanston, Wyoming

PURPOSE: The purpose of the first public workshop is to obtain the views of local residents, interest groups and public agencies concerning the effects of oil and gas development on wildlife in the Bear River Divide.

PROCEDURE: The primary role of the consultant at the first workshop will be to facilitate public comment and information exchange. The agenda for the workshop will be as follows.

7-7:20 pm: Presentation by Consultant

1. Purpose of Cooperative Wildlife Program
2. Project Team
3. Task Descriptions and Schedule for Phase I
4. Expected Products and Applications
5. Role of Public Participation

7:20-7:30 pm: General Questions by Public

7:30-9:30 pm: Public Testimony

1. Formal Presentations
 - a. Agency Representatives
 - b. Interest Groups and Organizations
2. Testimony by General Public

9:30-10 pm: Recapitulation and Summary by Consultant

1. Major Issues Presented
2. Relationships between Issues and Phase I Work Tasks
3. Close

SUMMARY OF COMMENTS AND QUESTIONS AT THE EVANSTON PUBLIC MEETING

The public meeting began with an introduction by Richard Harris. With this introduction Richard outlined the format for the meeting. Following Richard's introduction, Pat O'Brien from Chevron, who is serving as the Contract Administrator, described the scope of the entire cooperative wildlife study. Following his statement, Richard and Stan Anderson from the University of Wyoming, detailed the first phase of the project. Thereafter, Richard opened the meeting to public statements and comments, organizations first, followed by individuals.

The comments offered by those attending the meeting are summarized as follows:

Harry Harju, Supervisor of Biological Services, Wyoming Department of Game and Fish: The Department of Game and Fish has expressed its opinion on numerous occasions, indicating its concern over poaching, increased recreational demand including the increase in the number of hunters, subdivisions and road proliferation, loss of habitat through pad construction, etc. However, he said that the Department does not consider oil and gas development and wildlife to be incompatible if development is not allowed to proceed as it did three or four years ago.

He believed that the Game and Fish Department should be approached prior to development rather than being placed in a reactionary mode. He also made suggestions for industry as to future construction practices.

He concluded by saying that the study is a little late for the Bear River Divide area but that information usable up north in the future would likely come as a result. He felt the project was a step in the right direction and that the Game and Fish Department fully supports it.

Craig Kesselheim, Medicine Butte Wildlife Association: Listed four primary concerns of the MBWA. These include: 1) water quality in the Bear River Valley and the problems created by the nature, structure, and performance of zoning, service companies, sewage treatment, and the fact that Evanston is not "set up" to solve or handle the problems; 2) the rarity of riparian habitat and the pressure placed on it from development. He mentioned the Uinta County Bear River Wildlife Plan and the request of the county for the MBWA to map wildlife "hot spots"; 3) the permanent stability of wildlife populations in the face of residential development, interruption of migration routes, and poor reclamation practices. He complained of not being able to see any examples of reclamation (and wondered what the reclamation time line was) and of industry's failure to give the MBWA information on wildlife hotspots; 4) the need for wildlife studies to include investigations of areas of Uinta County that have not yet been affected by oil and gas development.

Brent Bergen, Wyoming Wildlife Federation: Stated that he felt better that the study is now underway but that he was still concerned about the conduct of Task 4. Restated a request made earlier in the day for comment sheets to be provided to individuals who would then distribute them to other concerned people in the area who could not attend the meeting. He said that he was concerned about what the end result would be on the ground and indicated that the WWF is going to submit a list of things that can be done now in the area of mitigation.

Mr. William Davis (Amoco Production Company): His primary concern was in the kind of information that can be obtained by talking to recent residents of the Evanston area. He said that those long-time residents who lived in the area prior to development and were familiar with previous conditions would be in the best position to comment on the kinds of changes that have occurred. He also indicated that coordination between the companies would be a good idea and that above ground pipes could, based on his understanding of the "Alaska experience", interfere with migration routes.

Mr. William Kates (Uinta County Planning Department): Speaking as an individual, Mr. Kates nevertheless indicated that the Uinta County Planning Department would like to be included in the mitigation analysis. He indicated a concern over soil waste from oil and gas wells; although he did not know what the impacts would be he thought that it deserved some attention.

Mr. Bernard Asay (U.S. Forest Service): He questioned how the companies would be bound by the findings of their study and what teeth the final document would have. He stated that the scope of work should cover both areas that have and have not been developed. Finally, he indicated his concern over the timeliness of the study.

Mr. Craig Kesselheim (MBWA): Speaking as a private individual, Mr. Kesselman indicated that he felt greater participation on the part of the citizenry was necessary. As a indication of the kind of participation possible, he suggested volunteer services to collect wildlife data. Middle school science class projects could, for example, be directed to the census of game birds, antelope, etc. A source of labor is ready and waiting to be tapped.

This comment by Mr. Kesselman appeared to be the last comment of the evening and Richard Harris asked if anyone had any additional comments or questions on anything related to the project. At the lack of response, he then indicated that the meeting would be ended.

Mr. Harry Harju (Wyo. DGF): When no additional questions seemed to be forthcoming, Mr. Harju asked whether or not the people understood what really was going on with the project and if they knew what the ultimate aim was.

No one responded and Richard Harris called for a short break, suggesting that the people present use it to think about anything they would like to ask before they left.

Just before the break, three individuals asked questions or offered comments.

A man from the MBWA (did not state name): He indicated a concern over the performance of water bars and furrows across pipeline rights-of-way.

Mrs. Edith Barnes: Indicated the importance of enforcement but questioned how it would occur.

Mr. Harry Harju: Stated that changes in regulations are necessary to control impacts on wildlife but simple solutions and corrective measures can result merely from informing industry of the problems that certain practices cause. He mentioned fences and roads as obstacles, topsoil storage, unnecessary blading, control over sidecast material, and open ditches with pipe laid alongside them for a lengthy period before placement. He suggested improvements in practices.

BREAK

Mr. Don Sweep, Bureau of Land Management: Stated that he hopes and believes that some useful recommendations will come from the project and that, although the BLM already requires certain measures (specific reference to reclamation), the recommendations could lead to improvements in BLM practices and requirements. He commented on the problems that checker-board ownership has on the uniformity of practices and indicated that 53-54% of the area is privately owned.

Mr. William Kates: He questioned the constituency of the Project Coordinating Committee.

Mr. Brent Bergen: Asked about measures that industry could take at the present time to mitigate impacts, reiterating his comment as a representative of the WWF.

Mr. Don Sweep: Commented on the progress that the BLM has been making and that current practices have changed as a result of the effort. He mentioned specifically reserve pit positioning on the well pad and the attempts made to plant 5-6 year-old sage. He questioned the economic and practical aspects of the latter planting program.

Two unidentified individuals questioned Sweep on revegetation practices and the kinds of plants used. The second individual questioned the palatability and erosion control properties of species used. In response, Sweep indicated that the BLM wants to use native plants to hold the soil in place.

Mr. Jim West, Chevron's PCC member: Stated that on private lands Chevron uses BLM specifications in reclamation but mentioned that landowners have the option of being paid for damages and may request payment and no reclamation. He also pointed out that damages can be sought through the court process if the landholder considers the reclamation effort to be unacceptable.

Mr. Don Sweep: Stated that the BLM tries to use native or near-native plant species and that crested wheatgrass is not considered to be an exotic species, and that it was used for several reasons. These include hardiness, ease in establishment, and wide use in the past. He did indicate that he recognized the species' relatively limited value as a wildlife food and that the BLM no longer includes it in its planting mixture (although industry still does). He indicated that it is very difficult to get shrubs established, particularly from seed, and that the success ratio for planting mixtures that have included both grass and shrub seed has been low. He stated that planting is more successful but more expensive.

Mr. Phil Riddell (District Supervisor, Wyo. DGF.): Mr. Riddell indicated that a spirit of cooperation has at last replaced one of confrontation, after three years of struggle. The companies needed to get educated about wildlife and Game and Fish needed to get educated about oil and gas development. He requested that old-timers educate new residents in the area as to the pre-development conditions and that the public as a whole participate "before it is too late". He concluded with a statement that the Game and Fish department does not consider oil and gas development and wildlife to be incompatible and that the Department is there to serve the public.

An unidentified man questioned the extent to which migration routes have been interrupted.

Mr. Phil Riddell: Answered the man by saying that routes are not defined lines. Problems are greater with antelope than they are with deer and elk because the latter are better jumpers. He said that fences are a big problem but that I-80 was "the biggest killer". Two other comments: antelope seem to accept development; increases in road traffic make it impossible for wildlife to use heavily networked areas.

APPENDIX B

ANNOTATED BIBLIOGRAPHY FOR TASKS 1, 2 AND 5

- The annotated bibliography for Tasks 1, 2 and 5 is presented in this appendix. The bibliography is organized by task and includes a brief description of the study, the author(s), the year of publication, and the location of the study. The bibliography is intended to provide a comprehensive overview of the research conducted in the field of wildlife management and conservation, and to identify the key studies and authors in the field.
- The bibliography is organized into three main sections: Task 1, Task 2, and Task 5. Each section contains a list of studies, with the following information provided for each study:
- Author(s)
 - Year of publication
 - Title of the study
 - Location of the study
 - Brief description of the study
- The bibliography is intended to provide a comprehensive overview of the research conducted in the field of wildlife management and conservation, and to identify the key studies and authors in the field.
- The bibliography is organized into three main sections: Task 1, Task 2, and Task 5. Each section contains a list of studies, with the following information provided for each study:
- Author(s)
 - Year of publication
 - Title of the study
 - Location of the study
 - Brief description of the study
- The bibliography is intended to provide a comprehensive overview of the research conducted in the field of wildlife management and conservation, and to identify the key studies and authors in the field.
- The bibliography is organized into three main sections: Task 1, Task 2, and Task 5. Each section contains a list of studies, with the following information provided for each study:
- Author(s)
 - Year of publication
 - Title of the study
 - Location of the study
 - Brief description of the study
- The bibliography is intended to provide a comprehensive overview of the research conducted in the field of wildlife management and conservation, and to identify the key studies and authors in the field.

Reference: Short, H.L.; Burnham, K.P. 1982. Technique for structuring wildlife guilds to evaluate impacts on wildlife communities. U.S. Department of the Interior, Fish and Wildlife Service. Special Scientific Report -- Wildlife No. 244. Washington, D.C.

Abstract

The described technique provides a means to organize and analyze information about wildlife species. "Guilding" involves dividing species into groups which utilize similar food sources and breeding niches. A two-dimensional "species-habitat" native is formed, with one axis representing food source, the other breeding habitat. Both axes are based on vertical location strata (tree canopy, terrestrial surface, terrestrial subsurface, etc.). The concepts were developed using a data base formulated from the literature on 275 species occurring in eastern ponderosa pine forest in southeastern Montana and northeastern Wyoming. Cluster analysis was used "to provide a statistical grouping of wildlife species that use similar resources within ecological communities (guilds)." The described analyses relate to the total wildlife community, and may be used in evaluating habitat quality, impact assessments, regional inventories and assessments of wildlife resources, and land-use planning activities.

Comments

The greatest difficulty in applying this technique is development of the required data base. If the system is expanded in the future to include more community types and wildlife species it may become considerably more useful.

Reference: Thomas, J.S. 1976. Guidelines for maintaining and enhancing wildlife habitat in the Blue Mountains of Oregon and Washington. Trans. 41st North American Wildlife and National Resource Conference Wildlife Management Institute, Washington, D.C. pp. 452-476.

Abstract

A system is described which can be used to predict the impact of forest management practices on wildlife. Essentially, the system consists of a large data base containing associations (feeding and reproductive) between all vertebrate species on the forest and habitat (plant communities and successional stages). Vertebrate species are divided into 16 "life forms" based on habitat requirements for reproduction and feeding. Information in the system is available at four levels of detail: 1) relationship of life forms to plant community and successional stage, 2) relationship of individual species to plant community and successional stage, 3) summary of available biological

data for each species, and 4) selected references on habitat relationships for each species. In addition, a vulnerability index is provided for each species, based upon the number of plant communities and successional stages used by the species. While the overall approach is to manage for all wildlife species, guidelines are provided for situations where it is desirable to manage for specific species.

Comments

The system is best suited for broad-scale (regional) application. It has been used in preparing land-use plans, environmental impact statements, and environmental analysis reports. While the system was developed specifically for the Blue Mountains of Oregon and Washington, the concepts involved should apply to any forested area.

Additional References

Thomas, J.W. (ed.). 1979.

Reference: Thompson, L.S. 1977a. Identifications of critical wildlife habitat using an "impact risk" mapping technique. Pages 421-442 in Anonymous. Classification inventory, and analysis of fish and wildlife habitat, proc. of a national symp. Phoenix, Az. 1977. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C.

Abstract

This procedure has been developed to produce a computer generated map of relative susceptibility to impacts. Such a map readily identifies critical wildlife habitat for use in project planning and mitigation, where critical habitat is defined as "areas where the risk of adverse impact to the wildlife resource is relatively greatest." The risk of adverse impact, or "impact risk", is related to the following parameters: 1) the relative "importance" of the wildlife resource (determined by such factors as abundance, reproductive potential, recreational value, scientific value, etc.); 2) the suitability of the area as habitat; 3) the distribution and habitat use patterns of the animals; and 4) the type and probable magnitude of impacts.

The procedure involves the following steps: 1) species of greatest concern are identified and ranked numerically, based upon several measures of relative importance and the relative magnitude of impacts; 2) a habitat map is prepared, and the habitat categories rated according to potential suitability of each species; 3) the distribution and seasonal use areas of each species are mapped; 4) the distribution maps and the habitat map are digitized by use of a raster scanner and combined; and 5) each resultant category is weighted according to the numerical ranking of its resident species as well as its suitability as habitat for those species.

Comments

The procedure is most applicable to cases of site-specific impact. It has been judged successful in applications to utility siting conducted by the Montana Department of Natural Resources and Conservation.

Additional References

Thompson, L.S. 1977b.

References: U.S.D.A. Forest Service. 1981a. Wildlife and fish habitat relationships, Volume I - Narratives; Volume II - Matrices. Rocky Mountain Region, Denver, Colorado. Volume I: 886 pp; Volume II: 331 pp.

Abstract

Region II of the U.S. Forest Service has developed a system for "integrating fish and wildlife habitat information and assessment data into the interdisciplinary land and resource management process." The system is centered around a data base which contains information on 853 vertebrate species which occur in the five states of Region II (Colorado, Kansas, Nebraska, South Dakota, and Wyoming). The data were compiled by biologists throughout the Region, and are organized into two major parts: narratives and matrices. Each narrative contains information on the species' legal status, distribution and habitat, special habitat requirements, spawning/breeding and feeding habits, territory and home range, and major literature references. The matrices are of two types: 1) status matrices which display information on legal status, occurrence, and associated life forms as described by Thomas (1979); and 2) habitat matrices which relate species to their use of habitat elements.

Habitat matrices for terrestrial species display information on the use of vegetative types, successional stages, and special habitat elements (snags, talus slopes, etc.) relative to reproduction, feeding, and nesting. Within each cell of a matrix, the agencies-habitat association is rated as 1 for optimum, 2 for acceptable, or 3 for marginal, based upon current literature and professional knowledge. Ratings for reproduction, feeding, and nesting are combined into an overall subjective numerical rating of habitat value to the agencies.

Habitat matrices for aquatic species contain a variety of aquatic habitat and micro-habitat elements. Species use of an element is listed as "required for survival", "not required for survival", or "unknown".

Comments

Information in the system will be continually refined. All matrix information has been computerized and is available in Fort Collins, Colorado. The

system is a regional part of a broader Wildlife and Fish Habitat Relationships program of the Forest Service.

Additional References

Sheppard et al. 1982.

Reference: Mooney, E.L., and Lonner, T.N. 1978. POSIM - A general wildlife population simulator. Pp. 631-640 in Highland, H.J., Nielsen, N.R., and Hull, L.G. (eds.). Proc. 1978 Winter Simulation Conference. December 4-6, 1978. Miami, Florida. 1051 pp.

Abstract

The computer model described was developed to simulate the population dynamics of a wide variety of game species. Two considerations which influenced the design of the model are: 1) a number of critical factors relate to the population dynamics of virtually all game animals; and 2) to be useful a simulator must work within the bounds of available data. Parameters incorporated in the model include mortality rates, fertility rates, and harvest rates, all of which may be specified by sex and age class in the population. The model will accommodate up to 12 mortality rates in response to weather or other environmental influences.

Comments

The model was developed by the Montana Department of Fish and Game, and has received limited application with deer and elk populations. The program is interactive (thus allowing immediate user interplay with the model, e.g., experimenting with harvest strategies or assumed rates) and operates on the Xerox Sigma 7 computer system at Montana State University.

Additional References

Anonymous, 1979.

Lonner, T.N., 1979.

Reference: Pfankuck, D.J. 1975. Stream Reach Inventory and Channel Stability Index. USDA Forest Service, Rocky Mountain Region, Denver, Colorado. 26 pp.

Abstract

In 1975, the Northern Region of the U.S. Forest Service developed an ocular watershed management tool entitled, "Stream Reach Inventory and Channel Stability Index" (SRICSI). Pertaining mainly to the hydraulic aspects of channel and streambank stability, this index provided an expedient method to evaluate the physical watershed condition. The index was developed primarily

for application on 2nd to 4th order mountain streams with its principal use being the assessment of resistive capacity of a stream channel to the detachment of streambank materials and channel substrates. While designed to evaluate individual stream reaches, insight into the hydrologic condition of an entire watershed may be gained through summation and averaging of the individual stream reach scores. In a recent study conducted by Eifert and Wesche (1982), SRICSI scores were found to display a significant linear relationship to trout population estimates. Additional comparisons with three habitat evaluation procedures resulted in similar findings. The ease, rapidity and inexpense of the SRICSI procedure, combined with its effectiveness on both a physical and biological assessment technique, can provide the investigator with a valuable tool in mitigative or impact assessment studies.

Reference: Russell, K.R., G.L. Williams, B.A. Hughes and D.S. Walsworth. 1980. WILDMIS - a mitigation and management planning system - demonstrated on oil shale development. Colorado Cooperative Wildlife Research Unit, Colorado State University, Fort Collins, Colorado. 152 pp.

Abstract

A wildlife management information system (WILDMIS) has been developed to address problems which include: 1) setting production objectives, 2) evaluating habitats and assessing impacts, 3) collecting and assessing environmental data for habitat evaluation, and 4) deciding among wildlife management actions. The system consists of two primary components, PATREC and MANALT. PATREC is a species specific method of habitat evaluation which has a basis in Bayesian statistics (i.e., conditional probabilities). Habitat is classified in one of two or more categories based upon its suitability for a particular species. Important habitat attributes are identified, and for each attribute an estimate is obtained of the conditional probability that the attribute is present in a given habitat category. Observed attributes at a site are then used to estimate the probability that the site represents a particular category of habitat. This probability is referred to as the "expected habitat suitability" index (EHS), and if habitat categories are "high density" and "low density" (the usual case) the EHS could be defined as the probability that the site represents high density habitat. By describing potential habitat changes in terms of the selected attributes, PATREC can be used to predict future conditions and assess impacts.

MANALT is a method for evaluating management alternatives in terms of the cost of implementation and the resulting benefits (as measured by population increases). The method is based upon conventional cost-benefit and budgeting procedures, but incorporates a probability of success factor and a management efficiency index which allow the consideration of external factors (such as severe weather) which can influence the success of management strategies.

Comments

This system has been applied by the Idaho Department of Fish and Game (Kuch, 1981) in a habitat assessment study related to phosphate mining in southeastern Idaho.

Additional References

Williams et al., 1978.
Kling, 1980.
Evans, 1981.
Flather, 1981.
Kuch, 1981.

Reference: Sheriff, S.L. 1978. Computer model for mountain lion populations. M.S. thesis. Colorado State University, Fort Collins, Colorado. 287 pp.

Abstract

The population simulation model (Program ONEPOP) developed by Jack Gross (Gross et al., 1973) has been modified for use with mountain lion populations. Two main changes have been incorporated in the revised program: 1) the reproductive scheme has been changed to allow births at all times of the year, and 2) the new model allows immigration and emmigration by age class and sex. Several biologists having prior experiences with mountain lions were called upon to test the validity of the model. The model was shown to have potential for testing hypotheses about input data and for testing the effects of different management options. Although the model was developed specifically for mountain lions, it is suitable for other species with similar life histories and has been applied to a bear population.

Comments

The model appears to have very limited potential relative to use in the Overthrust study due to limited species applicability and the lack of data on mountain lions in the area.

Additional References

Gross et al, 1973.

Reference: Asherin, D.A., Short, H.L., and Roelle, J.E. 1979. Regional evaluation of wildlife habitat using assessment methodologies. Trans. North American Wildlife Natural Resource Conference. 44:404-424.

Abstract

This procedure was developed as a time-efficient means to evaluate habitat quality on a regionwide basis and to mitigate development impact by providing a measure of the relative value of wildlife in different areas. The procedure relies primarily on recent aerial photography, which is interpreted according to vegetative composition and structure, land use, and special interest features (presence of endangered species, cliffs, etc.). Two basic assumptions are made: 1) habitat quality is a direct function of habitat diversity for the majority of terrestrial vertebrate species; and 2) characteristics that contribute to the diversity of wildlife habitat such as interspersions of different vegetation or cover types, canopy cover, vegetative strata present, quantity and quality of edge between vegetation types, presence and distance to water, and unique physical features can be assessed from aerial photography. Cover information obtained from the aerial photographs is digitized and used to predict bird species diversity (BSD) which serves as a measure of overall wildlife habitat quality. Regression equations for the prediction of BSD were developed using breeding bird surveys on a study area in southeastern Montana.

Comments

The procedure was developed by the Western Energy Land Use Team of the U.S. Fish and Wildlife Service. It was designed to be coupled with a geographic information system for rapid assessment and mapping of wildlife habitat quality for large regions.

Additional References

Asherin, D.A. 1979.

Reference: Bartholow, J.M. 1981. POP50 system documentation. 12pp. (Mimeo)

Abstract

The POP50 computer program is a simulation model for populations of big game species. The model is the offspring of Program ONEPOP developed by Jack Gross (Gross et al. 1973) but incorporates a number of substantial changes. A major operational difference in the two models is that POP50 was developed for interactive operation on a Tektronix micro-computer using the Tektronix BASIC language whereas ONEPOP was written in FORTRAN IV and designed to operate in batch mode on a large, central computer system. Other changes in POP50 include the use of mortality severity index to model the relative harshness of conditions for survival over time, improved graphics, and elimination of several little-used capabilities of ONEPOP. Additions to the program are difficult because of size limitations of the micro-computer.

Comments

POP50 is currently used quite extensively by the Wyoming Game and Fish Department to simulate mule deer, antelope and elk herds. The Department has sponsored efforts to incorporate a new option in POP50 which may provide a means of evaluating the effects of environmental change on population dynamics. The Colorado Division of Wildlife is presently making some use of POP50 and may expand this use in the future (Thomas Pojar personal communication).

Additional References

Bajusz, B. 1982.

Reference: Binns, N.A. 1979. A Habitat Quality Index for Wyoming Trout Streams. Wyoming Game and Fish Department, Fishery Research Report No. 2, Cheyenne, Wyoming.

Abstract

Binns (1976, 1978 and 1979) devised a habitat evaluation procedure, termed the Habitat Quality Index (HQI), designed to quantify aquatic habitat and predict trout standing crops in Wyoming streams. Based upon measurements of trout habitat collected from 36 streams that ranged in elevation from 1,146 to 3,042 meters, two predictive models were subsequently developed. Of these two models, Model II has been found to be most highly correlated to trout standing crops. Habitat parameters evaluated include late summer streamflow, annual streamflow variation, water velocity, cover, width, eroding banks, substrate, nitrate concentration, and maximum summer stream temperatures. Application of these procedures proved quicker, easier and cheaper than conventional electrofishing techniques. Additional application of the HQI has proven beneficial in instream flow-related impact assessments, evaluation of habitat improvement potential, and in the documentation of habitat improvement potential, and in the documentation of habitat degradation.

Reference: Bovee, K.D. 1982. A guide to stream habitat analysis using the Instream Flow Incremental Methodology. Instream Flow Information Paper 12. U.S.D.I. Fish and Wildlife Service, Office of Biological Services. FWS/OBS-82/26. 248 pp.

Abstract

The Physical Habitat Simulation (PHABSIM) System models are the heart of the Incremental Method developed by the USFWS Instream Flow Group for assessing the effects of streamflow regimes of fish habitat and communities. A collection of computer programs are used to relate changes in discharge or channel structure to changes in physical habitat availability. The underlying principles of PHABSIM are that: 1) each species exhibits preference within a range of habitat conditions that it can tolerate; 2) these ranges can be

defined for each species; and 3) the area of stream providing these conditions can be quantified as a function of discharge and channel structure. While the solution of instream flow-related problems is the major use of this model, it can also be used for impact analysis for channel modification projects using habitat time series of duration curves, and in cost-efficient analyses for habitat improvement.

Reference: Daniel, C. and Lamaire, R. 1974. Evaluating effects of water resource developments on wildlife habitat. Wildlife Society Bulletin 2(3):114-118.

Abstract

This method of habitat evaluation was developed to measure the effects of water resource development on wildlife. It is based upon two fundamental concepts: 1) all land has some value to wildlife with or without project development, and 2) the effects of a water resource project on wildlife habitat can be expressed numerically. The basic approach is to have a team of wildlife biologists subjectively evaluate habitat components on a scale of 0 to 10. Habitat types are identified from aerial photographs and representative sample sites are selected from each type for field inspection. Habitat variables considered in the evaluation include plant density, understory, the relative abundance of plant species important to wildlife, degree of grazing, and interspersation. The method gives equal consideration to game and non-game species and allows extra value to be attributed to the existence of rare or unique species and communities.

Comments

The procedure of Daniel and Lamaire provided the initial framework from which the HEP system (U.S. Fish and Wildlife Service, 1980b) evolved.

Reference: U.S. Fish and Wildlife Service. 1980b. Habitat Evaluation Procedures (HEP). ESM 102. U.S.D.I. Fish and Wildlife Service, Division of Ecological Services, Washington, D.C.

Abstract

Since 1973 the U.S. Fish and Wildlife Service has been involved in the development of a nonmonetary method of environmental evaluation. The system of procedures which has evolved (HEP) is based on the assumption that physical, chemical, and biological components of habitat can be incorporated into an index of habitat quality which is proportional to carrying capacity. Habitat quality is depicted as a more practical and/or stable method of evaluation than other methods such as energy flow analysis of population estimation.

A HEP analysis is structured around "habitat units," which are a measure of habitat quality and quantity. Habitat units are determined as the product of area times a "habitat suitability index," (HSZI). The HSI is a ratio which relates observed habitat conditions in a particular area to optimum habitat conditions (and thus ranges from 0 to 1.0). To calculate the HSI, a model is developed which incorporates important, measurable habitat variables from a particular species, life stage, or group of species. The model is based upon relevant literature or expert opinion and attempts to produce an index based upon habitat features which has a direct relationship to carrying capacity.

A study region is divided into homogeneous regions based on cover type. The HSI model is then applied to each cover type, and summing the product of area and HSI over cover types determines the total habitat units for the study region. Determination of habitat units allows two types of comparison: 1) comparison of the same area of different points in time (e.g., impact assessments), and 2) a comparison of different areas at the same point in time (e.g., evaluation of mitigation alternatives).

Comments

HEP are the most comprehensive, the best documented, and the most extensively applied procedures reviewed in this study. The procedures were developed specifically to address problems related to impact assessment and mitigation.

Additional References

- Schamberger, M. 1982.
- Schamberger, M. and A. Farmer. 1978.
- Schamberger, M. and W.B. Krohn. 1982 (in press).
- Short, C. 1979.
- U.S. Army Corps of Engineers. 1982.
- U.S. Fish and Wildlife Service. 1980a.
- U.S. Fish and Wildlife Service. 1980c.
- U.S. Fish and Wildlife Service. 1981.

Reference: Walters, C.J. 1969. A generalized computer simulation model for fish population studies. Trans. Amer. Fish. Soc. 3:505-512.

Abstract

The model presented was developed for fish population simulation and maximum yield determination. The primary goal in this development was for the model to be able to evaluate the response of fish populations to fishing, as a means of analyzing management strategies. The model makes use of the following assumptions: 1) spatio-temporal variations in fishing effort and fish distribution can be ignored or characterized by some overall catchability relation; 2) a reproducible relationship exists between spawning stock and

resulting progeny; and 3) the environment is stable or acts on the population by producing predictable changes in growth, mortality, or reproductive rates. The model utilizes age-specific natural mortality rates, growth rates, relative fecundities and allows the user to supply the desired stock-recruitment relationship.

Reference: Wesche, T.A. 1980. The WWRI Trout Cover Rating Method, Development and Application. Water Resources Series No. 78. University of Wyoming, Laramie. 46 p.

Abstract

Wesche (1973, 1974, 1980) developed criteria defining the cover preferences of trout. Using substrate diameters, overhead bank cover and water depth, this procedure, developed and tested by the Wyoming Water Resources Research Institute, is used to quantitatively evaluate the in-channel and bankside cover features of stream habitat. Especially applicable for use on streams dominated by brown trout, recent studies by Eifert and Wesche (1982) indicated a linear relationship also exists between WWRI Mean Cover Ratings and fish populations composed primarily of brook trout. As the habitat outputs of the procedure have been found to significantly correlate with standing crops of trout supported, it could be used as an indicator concerning relative changes in carrying capacity based upon various development scenarios.

Reference: Whitaker, G.A. and McCuen, R.H. 1975. A proposed methodology for assessing the quality of wildlife habitat. Department of Civil Engineering, University of Maryland, College Park, Maryland.

Abstract

This method was developed to evaluate terrestrial habitat quality through consideration of three major components: the degree of interspersions of land uses, the quantity of each land use (relative proportion), and the management or vegetative condition of each land use. Using transformation curves and tables, observed conditions are created on a scale of 0 to 1 with regard to their relative value for wildlife (single species or groups of species). Weights are then assigned to observed conditions over all three major habitat components to reflect relative importance. A weighted geometric mean provides an index to overall habitat quality.

A description of an application of this method (in Delaware and Maryland) is provided which should allow the method to be applied elsewhere. A team of wildlife biologists must calibrate the model to a specific area, developing the necessary transformation curves and tables. Then, field technicians can apply the method using aerial photographs and field evaluations of random points.

The method provides a means of comparing the effects of alternative land use proposals on the quality of wildlife habitat. Projected changes in habitat components due to various proposals can be measured by changes in the index of habitat quality. The relative size of such changes can be used to address mitigation strategies.

Comments

The method has been applied to several USDA Soil Conservation Service Projects in the Eastern United States.

Additional References

McCuen, R.H. and G.A. Whitaker. 1975.

Reference: Williamson, J.F. Jr., Whelan, J.B., and Mead, R.A. 1978. A computerized wildlife habitat information system. Paper presented at PECORA IV Symposium: Application of remote sensing to wildlife management. Sioux Falls, South Dakota.

Abstract

The proposed system is designed to evaluate wildlife habitat and display qualitative differences in the form of computer generated maps. Major habitat factors for a given species are identified and ranked on a scale of 1 to 10 in relative importance. Levels, or intensities, of each factor are linearly stratified and assigned values from 1 to 10. A qualitative habitat rating is calculated as the sum, over all factors, of the product of the factor importance rank times the value for the observed level of that factor. Output is in the form of a line printer generated map which displays habitat quality with one of 10 grey-tone symbols. A vegetative system for time event simulation is proposed as a means of estimating future habitat potential.

Comments

The system was developed for forested areas in the eastern United States. predictive capabilities are directed toward comparison of timber harvesting strategies.

Additional References

Whelan, et al. 1979.

Reference: Willis, R. 1975. A technique for estimating potential wildlife populations through habitat evaluations. Pittman-Robertson Game Management Technical Series No. 23. Kentucky Department of Fish and Wildlife Resources.

Abstract

This technique is designed to evaluate an area carrying capacity for game species based upon habitat suitability as measured by characteristics of cover and food availability. The basic steps in the process are: 1) the vital elements of habitat are identified from previous studies for each species of interest; 2) for each element a numerical rating system is established which assigns a value between 5 and 20 based upon an area's relation to the optimum condition; 3) values are summed over all elements; and 4) based on the sum of the ratings, an area is ranked as excellent, good, fair, or poor habitat and assigned a corresponding carrying capacity (estimated from the available literature).

In the hypothetical example presented, aerial photos are used to map cover types, which are subsequently verified in the field. A sampling scheme is outlined with which to estimate the required habitat elements.

Comments

The technique as presented would provide only a rough guideline for use in the Overthrust study region. The sampling scheme and species criteria presented for Kentucky would require considerable modification or outright replacement.

Reference: Winn, D.S. 1982. WILDRAM progress report. Wildlife and fish habitat relations workshop, Portland, Oregon, March 24-27, 1982. U.S.D.A. Forest Service, Intermountain Region, Ogden, Utah. 43 pp.

Abstract

The Intermountain Region of the U.S. Forest Service is developing a computer program (WILD RAM) for data retrieval and analysis of wildlife habitat information. Central to the system is a data base of information on vertebrate species and relations with 87 floral and aquatic communities. The data base includes: 1) species records by forest service biologists on occurrence and preference of wildlife species for community types; 2) matrices which display relationships of wildlife breeding, feeding, and resting to communities in the form of community importance and seasonal use codes; and 3) an extensive literature summary. The WILD RAM system also contains program components relating specifically to terrestrial relationships and to aquatic relationships, which are directed toward inventory and analysis of habitat and consideration of project alternatives. The system is directed toward evaluation of all vertebrate species but HSI (U.S. Fish and Wildlife Service, 1981) or similar models can be included when species specific information is needed. In addition, the system incorporates forest succession models which can be used to predict future conditions.

Comments

WILD RAM is a part of the Wildlife and Fish Habitat Relations program of the U.S. Forest Service, which includes multiresource considerations, of which wildlife is one aspect. Software for WILD RAM is currently operational in Fort Collins, Colorado. The system is subject to updating and expansion.

Additional References

Winn, D.S. 1980.

Reference: Duff, D.A., and J.L. Cooper. 1978. Techniques for conducting stream habitat surveys on National Resource Land. U.S.D.T. Bureau of Land Management. Technical Note No. 283. 73 pp.

Abstract

The BLM, in conjunction with the U.S. Forest Service, developed procedures for conducting physical, chemical and biological habitat surveys on National Resource Land. Designed primarily to be used in preparing Environmental Impact Statements, Habitat Management Plans or Management Framework Plans, the major objectives of the surveys are to insure the existence of adequate environmental conditions pertaining to aquatic habitat availability and fish production. The surveys consist of both ocular and transect techniques dependent upon the level of intensity required. Three survey levels are currently available, with options including either cold or warm water fisheries, or lentic or lotic aquatic habitat types. Each survey level is further subdivided into Priority "A" or "B" Limiting Factors. The division between categories was determined on the significance of the habitat parameters with respect to fish production, with Priority "A" factors being the most critical. Dependent upon the level and intensity of the survey type employed, the results have been utilized in habitat improvement projects, special habitat management plans, habitat or fisheries trend studies, or in administrative or research investigations.

Reference: Graber, J.W. and Graber, R.R. 1976. Environmental evaluation using birds and their habitats. Biological notes no. 97, Illinois Natural History Survey. State of Illinois, Department of Registration and Education, Natural History Survey Division, Urbana, Illinois.

Abstract

This method of environmental evaluation uses bird populations and their gross habitats as a means of determining general biological richness. It is based on the belief that the variety of birds in a given area reflects the overall complexity of a habitat and the general value to wildlife. Five general habitat factors are considered in the evaluation: 1) the replacement

cost of habitat in time, 2) the availability of each habitat based on total area in the region, 3) the changing availability of each habitat, 4) the amount of each habitat in the impact area, and 5) the faunal, and/or floral complexity of each habitat. Aerial photographs, maps and field measurements are used to determine the acreage of gross habitats in a study area. Two evaluation indices are calculated in the analysis, a Habitat Evaluation Index which basically measures the potential value of habitats, and a Faunal Index which attempts to measure actual biological value based on species variety and species rarity.

Comments

Although the procedure has been developed for use in Illinois, it could be applied elsewhere if sufficient data exist on bird populations and habitat availability. As described, the procedure is concerned with evaluating baseline conditions and does not address prediction of future potential.

Reference: Gross, J.E., Roelle, J.E., and Williams, G.L. 1973. Progress report, program ONEPOP and information processor: a systems modeling and communications project. Colorado Cooperative Wildlife Research Unit. Colorado State University. Fort Collins, Colorado.

Abstract

A computer model (ONEPOP) was developed by Jack Gross and his associates at the Colorado Cooperative Wildlife Research Unit. The model was designed to simulate the population dynamics of big game species. Computations are centered around a simulation year which may be divided into as many as 12 mortality periods. Estimates of the initial population size of a herd must be input by sex and up to 20 age classes. During a simulation, population size and structure for the next year are computed from last year values, natural mortality, harvest and reproduction. Mortality (natural and harvest) must be specified for each of the designated mortality periods and, in a multiple year simulation, three complete sets of mortality rates may be used to allow mortality to vary between years. In addition, the model allows for sex and age-specific harvest. Reproduction may be entered in the form of an annual reproductive rate, the number of young to be added to the population, or as a density dependent regression relation. Additional features in ONEPOP allow optional calculation of the value of the population, the value of a harvest, annual energy consumption, and the number of animal-unit-months of grazing utilized by the herd.

Comments

Program ONEPOP originated much of the ongoing interest in population simulation as a tool in game management. ONEPOP is used by a number of state game management agencies, including those in Colorado, Idaho, and Wyoming. The current interest among management agencies, however, appears to be in the direction of easier to use, micro-computer oriented program.

Additional References

- Gross, 1973.
 Roelle and Bartholow, 1976.
 Pojar and Strickland, 1979.

Reference: McClue, J.P., Cost, N.D. and Knight, H.A. 1979. Multiresource inventories - A new concept for forest survey. U.S. Department of Agriculture Forest Service Research Paper SE-191. Southeastern Forest Exp. Station, Ashville, NC.

Abstract

The U.S. Forest Service has developed, as part of an expanded inventory system, a geobased method for assessing the value of forest and rangeland as wildlife habitat. Relevant literature and expert opinion were used to develop habitat criteria for 12 species (and species groups). For species without specialized habitat requirements, important habitat variables are assigned numerical values and sample habitat are ranked good, fair, or poor on the basis of total value over all variable. Species with specialized habitat requirements (nest cavities, caves, etc.) are treated under a separate system which classified habitat as good, fair, or no habitat. All habitat ratings are associated with specific geographic locations and can therefore be mapped.

Comments

This method is directed toward evaluating base line conditions and is not designed for assessment of alternative scenarios. It was developed for use in the southeastern United States, but could be applied elsewhere.

Additional References

- Adams, D.A. 1980.

Reference: Medin, D.E. and Anderson, A.E. 1979. Modeling the dynamics of a Colorado mule deer population. Wildl. Monogr. 68:1-77.

Abstract

A computer model was constructed to simulate the population dynamics of a Colorado mule deer (Odocoileus hemionus hemionus) herd. Two objectives were that the model produce results which were consistent with field data and that the model be useful in comparing alternative harvest strategies. The model developed consists of two submodels, a population submodel and an environment submodel. The population submodel incorporates the primary components of mule deer population dynamics: population size, sex and age composition, mortality rates, and harvest rates. In addition, the population submodel contains a

density dependent feature in which a multiplier is used to modify the birth rate in response to changes in midwinter density. The environment submodel essentially relates precipitation to birth rate, and will generate a random input value for April through July precipitation to allow simulations to extend into the future.

Comments

The model is stated to be useful in identifying parameters for which the simulation (and hopefully the population itself) is sensitive to change, and in determining data needs for a better understanding of the real system.

Reference: Delbecq, A. L., A. H. Van de Ven, and D. H. Gustafson. 1975. Group techniques for program planning: a guide to nominal group and delphi processes. Scott, Foresman and Company. 174p.

Abstract

The book contains five chapters, two devoted to decisionmaking in organizations and small groups, one each on the Delphi Method and the Nominal Group Technique, and one on applications in planning situations. The chapters on decisionmaking compare the two methods within contemporary organization and planning contexts. The last chapter, on applications, is oriented essentially toward Nominal Group Techniques.

These methods or techniques offer ways to facilitate collaborative planning and analysis by providing structured formats for obtaining judgments from resource experts, outside interest groups, agencies, etc. Both have advantages over non-structured alternatives. Among these are the production of more specific and high-quality ideas, control to insure balanced participation, and mechanisms to focus attention on the problems rather than on the personalities of the participants. The methods, however, establish these advantages in different ways.

In the Delphi Method, the decisionmakers use a staff group to design questionnaires for distribution to members of a respondent group who do not meet and remain anonymous to one another. Through a sequence of questionnaires and interspersed summaries of respondent information (which provide the basis for subsequent questionnaires), the staff group obtains answers to a series of questions.

Nominal Group Technique participants meet face to face in meetings controlled by staff persons. As with the Delphi Method, the staff is (or can be) a disinterested third party. At a NGT meeting, participants silently generate ideas in response to a statement or question asked by the staff. Round-robin procedures are used to place these ideas on a flip chart (standard) and to discuss each. Individual voting is used to rank ideas but group discussion can be used to adjust initial priorities.

Comments

Either of these methods could be used by the OIL or the PCC to assist them in collaborative analysis of problems in the Overthrust Belt. Both methods can be used to rank alternative development and management plans, to obtain opinions as to the type and importance of impacts they could have, and to obtain suggestions for mitigation measures. However, neither method seems to provide the opportunity considering the relationships between the ideas (identified impacts, suggested mitigation measures) and their joint importance in an overall ecological context.

Additional references

Delbecq, A. L. 1967. The management of decisionmaking within the firm: three strategies for three types of decisionmaking. Acad. Mgt. Jour. 10(4): 329-339.

Van de Ven, A. H., and A. L. Delbecq. 1972. A planning process for development of complex regional programs. In Proceedings of the American Sociological Association Annual Meetings.

Dalkey, N. C., and O. Helmer. 1963. An experimental application of the Delphi method to the use of experts. Manage. Science (pages not given).

Reference: ESSA, Ltd. 1982. Review and evaluation of adaptive environmental assessment and management. Summary report of a workshop of AEAM. Environment Canada. 89p.

Abstract

This review contains the results of a workshop held for practitioners and clients to evaluate AEAM. It offers criteria for success and then evaluates all previous AEAM applications in terms of these criteria. Summary statements provide information on how both practitioners (workshop facilitators) and clients rate AEAM's utility in environmental impact assessment, research planning, resource management and policy development, and project integration and synthesis. Objectives within each of these four areas can include identification of issues and unknowns, identification of impacts, improvement of communication, synthesis of information, planning research, policy analysis, and management of projects. The appendix includes a complete list of previous applications.

The most frequent applications of AEAM have been undertaken to identify issues and unknowns (variables about which little is known) and to improve communication. Issue identification applications were considered successful in the former and attempts designed to improve communication have been highly

successful. Applications within which the primary objective was impact identification were moderately numerous and moderately successful. Information synthesis and research planning were moderately frequent objectives and AEAM applications were rated as being moderately successful in both cases. Policy analysis and project management applications were few; policy analysis applications were successful, management applications ineffective.

Comments

ESSA's review and evaluation complements the IIASA review referenced below but both should be accompanied by interviews with users. This review seems reasonably objective but is not particularly critical.

Additional references

International Institute for Applied Systems Analysis. 1979. Adaptive environmental assessment and management: current progress and prospects for the approach. Draft summary report of the first policy seminar. 125p.

Reference: Holling, C.S. 1978. Adaptive environmental assessment and management. John Wiley and Sons, New York, New York, USA. 377p.

Abstract

This textbook is the basic document describing Adaptive Environmental Assessment and Management in its state of development as of 1978. It describes the approach step by step and discusses the perspective managers must have to use the approach and manage in truly flexible, adaptive fashion. The book also illustrates AEAM applications with several case study examples. Appendices outline the techniques used in the applications and identifies the Leopold Matrix, Kane and Gallopian simulation methods, and computer simulation modeling as possible techniques. The choice of a technique is recognized as a function of the complexity of the problem, the understanding on the part of the analysts, and the type, amount, and quality of data available.

AEAM couples workshops with one of the above techniques. The textbook, however, does not consider workshops in great detail and places an overemphasis on the use of computer simulation modeling. The process of undertaking an application is handled in three chapters but the bias is toward workshops centered on computer simulation modeling. A chapter is included on communication, but too little information is available on meeting management and the group of techniques used to insure that the workshop participants contribute equally and completely.

The text also includes a chapter on the Wildland Impact Information System (WIIS) developed by the Office of Biological Services of the U.S. Fish

and Wildlife Service. The system is described and briefly illustrated using a tract for which oil shale development was proposed in northwest Colorado.

Comments

The textbook is a good introduction to AEAM and its underlying philosophy. It has been complemented by the review organized and prepared by ESSA, which is intended to update the textbook. The book provides an essentially noncritical outlook with little discussion of possible shortcomings or the effect the sophisticated and legal settings can have on the success of applications.

Additional References

ESSA, Ltd. 1982. Review and evaluation of adaptive environmental assessment and management. Summary report of a workshop on AEAM. Environment Canada. 89p.

Keeney, R. L., and H. Raiffa. 1976. Decisions with multiple objectives. John Wiley and Sons, New York, New York, USA.

Watt, K. E. F. 1968. Ecology and resource management: a quantitative approach. McGraw-Hill Company, New York, New York, USA. 450p.

Reference: International Institute for Applied Systems Analysis. 1979. Adaptive environmental assessment and management: current progress and prospects for the approach. Draft summary report of the first policy seminar. 125p.

Abstract

This publication summarizes the first IIASA Policy Seminar, which focused on Adaptive Environmental Assessment and Management. The seminar drew together senior administrators who have used the method. The purpose of the seminar was to analyze AEAM's successes and failures in application and to identify future ways for improving it. Five papers were presented, three describing agency applications (Canada Department of Fisheries and Oceans, U.S. Fish and Wildlife Service, Canadian provincial and federal forestry agencies), one presenting an American industrial viewpoint, and one describing the changes and challenges in environmental management, drawing heavily from the experience of the United Kingdom Departments of Environment and Transport.

The Canadian forestry applications centered around the development of a spruce budworm-forest dynamics model to aid in the discovery and evaluation of policies for managing the forest to minimize the impacts of the budworm. These AEAM applications can succeed because the users understand its potential utility. However, the eventual successful inclusion of AEAM and its philo-

sophical framework into the management process will depend upon how individual and institutional resistances are overcome. The Fish and Wildlife Service illustrated AEAM through three examples and described its workshop staff's current abilities as being currently incompletely developed. The Industrial representative stated that AEAM focuses environmental assessments on how systems work rather than on the collection of unusable masses of data, that it can effectively assist scoping, and that it provides a good conceptual framework within which to consider uncertainty. The United Kingdom experience indicates AEAM would succeed if it could: 1) frame a problem that concerns the environmental scientist, the developer, and the regulatory authority in terms all three could understand; 2) reduce the potential for overlooking critical interactions; and, 3) assist in distributing the responsibility for decisions that have "failed" in the face of unanticipated outcomes. Successful applications would be likely if they would cost no more than previously used methods.

Comments

AEAM offers the potential for collaborative analysis on the part of the PCC agencies. This summary report does not describe how the method is employed but suggests how it has been used to overcome institutional management problems. The contributors illustrate the method's collaborative and analytical potential through practical, real-world problems.

Additional References

Holling, C. S. 1979. Adaptive environmental assessment and management. Wiley and Sons, New York, New York, USA. 377p.

Reference: Power, M. A. 1975. Computerized geographic information systems: an assessment of important factors in their design, operation, and success. Report No. CDTDM-R(T)-75/3 THA-75/9. Center for development Technology Program on Earth Observation Data Management Systems and Program in Technology and Human Affairs. Washington University, St. Louis, Missouri. 166p.

Abstract

This report contains the results of a study that was part of the Earth Observation Data Management Systems project. Its purpose was to compare existing systems and it relied heavily upon previously completed work. Chapters two through four constitute the heart of the report. The second chapter outlines the elements of a geographic information system, the third chapter discusses key decisions that must be made (data type, coordinate system, user needs, accuracy, etc.) before a system is installed, the fourth chapter describes several state and regional systems, and the fifth chapter assesses them in simple terms (do they run? do they have users? and are the users satisfied?).

Comment

An introductory description of systems that is well-written and very readable. Valuable companion document to the review by Schneider and Amanullah but of lower technical quality and with less usable information.

Additional References

Tom, C. and L. D. Miller. 1974. A review of computer-based resource information systems. Land Use Planning Information Report No. 2. Colorado State University, Fort Collins, Colorado.

Schneider, D., and S. Amanullah. 1979. Computer-assisted land resources planning. Report No. 339. Planning Advisory Service, American Planning Association. 46p.

Dyer, H. L. 1975. Information systems for resource management and related applications. Two volumes. Argonne National Laboratory.

Reference: Schneider, D., and S. Amanullah. 1979. Computer-assisted land resources planning. Report No. 339. Planning Advisory Service, American Planning Association. 46p.

Abstract

This report is an excellent description of the ways in which computerized geographic and data base management systems can be used to assist land use planning. It describes computerized systems in terms of the hardware, software, personnel, and other administrative requirements (costs, time, promotion of the system). To assist agency or organization personnel investigating existing systems as part of the process of acquiring one, the report includes an appendix describing existing systems, offering agency contacts, and listing computer associations, conferences, and periodicals.

Computerized and manual information systems offer the same types of products. The choice between one or the other is a matter of costs, data storage requirements, and the data manipulation and analysis capabilities desired. Computerized systems offer cost (and time) advantages once the initial costs have been incurred if the system receives heavy use. If large volumes of data must be stored and the types of analyses to be conducted are complex and require tedious, repetitive calculations, computerized systems have advantages over manual systems.

In illustrating data manipulations useful in the planning process, the report describes polygon and cell data structures, conversions from one structure to the other, searching, compositing and overlaying, and networking and routing capabilities. Specific planning problems to which these computer

techniques are suitably applied include: the identification of development limitations and opportunities; zoning, subdivision, and plan review; the evaluation and testing of alternatives; water quality and resource management programs; protection of prime agricultural land; and facilities planning.

One chapter contains an understandable description of the technical components of a computerized geographical information and data base management system and defines terms commonly used in systems descriptions. Hardware and software requirements are described in simple lay terms as is the process of creating a computerized data base. A detailed list of questions is provided for use by the potential purchaser in questioning system vendors. These cover hardware, software, and management considerations. Finally, the personnel requirements for maintaining and operating the system and the data bases are reasonably thoroughly assessed.

Comments

This report is an excellent introduction into computerized geographic information and data base management systems. Its utility to the OIA would be limited. PCC agencies without well-developed plans for future system development (State of Idaho) would find the report useful as would members of other PCC agencies who would like to learn something about what their agencies' systems will be capable of when they become operational.

Reference: U.S. Fish and Wildlife Service. 1979. Proceedings of the rapid assessment methodology: a demonstration conference. Western Energy and Land Use Team, Office of Biological Services. Report No. W/CRAM-79/W36. 91p.

Abstract

This proceedings is the primary document available from the Western Energy and Land Use Team (WELUT) on the computerized system that supports the Rapid Assessment Methodology (RAM). It includes contributions from Region Six personnel, system architects, project officers, and other personnel in WELUT's RAM and Systems Applications Groups. Hardware and software are described and examples are given illustrating the systems capabilities in coal lease tract ranking and in the Operational Coal Program.

MIS, WAMS, MOSS, and MANAGE are described. MIS is the Map Indexing System used to store and document data bases and information on potential data bases. WAMS (Wetland Analytical Mapping System, now AMS) is used as the data entry vehicle and is applied primarily to transform hand-drawn maps air photo oneclays, etc. into computerized, digital form. MOSS (Map Overlay and Statistical System) is the software used to statistically summarize information available on maps, to composite maps, and do resource analyses. MANAGE is a general-purpose data base management system that can be used to manage non-spatially referenced data as well as map-related data.

These four software packages support a number of rapid applications that are called RAM applications. Among these are: 1) wildlife and wildlife habitat characterization, including bird species diversity and habitat diversity calculations; 2) lands unsuitable for mining (LVM) analysis to identify the conflicts that would be created by mining coal; 3) procedures and processes for ranking alternative coal mining tracts. These examples illustrate that the products obtained using the computerized system are not unique, that they can be obtained by hand but at much greater cost in time and labor.

COLLABORATIVE PLANNING CONSULTING FIRMS

Comments

RAM Group projects report are relatively few. No reports describe applications and evaluated them in terms of their success. Since this proceedings comes from a demonstration conference, assessments of the shortcomings and difficulties in the applications are lacking. Therefore, errors and system faults are not described and the true potential is not completely portrayed. Nevertheless, the proceedings illustrates applications that should be of interest to both the OIA and the PCC.

TASK 1. APPENDIX C.

Specialized Management Services Offering General Process Management Services

TASK 1. APPENDIX C.

APPENDIX C

COLLABORATIVE PLANNING CONSULTING FIRMS

Collaborative Planning Consulting Firm 140 West 51st Street New York, NY 10020 [212] 248-1829; [212] 484-4000 Donald B. Stinson, President of the American Arbitration Association	Clark-McGinnon Association 148 State Street Boston, MA 02109 [617] 742-1880; [617] 1334-525 Peter B. Clark/John A.S. McGinnon, Principals
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Office of Mediation Services 2100 K Street, N.W. Washington, DC 20005 [202] 823-8200 Jerome Barrett, Assoc. Dir. Harold E. Davis, Natl. Representative	Center for Conflict Resolution 188 Berry Street San Francisco, CA 94107 [415] 777-0392 Charles Symons, Director
Form on Community and the Environment 240 University Avenue Palo Alto, CA 94301 [415] 321-7347	Betsy Densmore 1008 G Street, N.E. Boulder, CO 80501 [303] 444-1301
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TASK 1. APPENDIX C.Organizations and Individuals Offering General Process Management Services

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TASK 1. APPENDIX C.Organizations and Individuals Offering General Process Management Services
(continued)

Interaction Associates, Inc. China Basins Building, Suite 150 185 Berry Street San Francisco, CA 94107 [415] 864-2590; [415] 777-0590	Office of Environmental Mediation Engineering Annex, FM-12 Institute of Environmental Studies University of Washington Seattle, WA 98195 [206] 543-6713
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TASK 1. APPENDIX C.

Organizations and Individuals Offering General Process Management Services (continued)

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Western Energy Land Use Team U.S. Fish and Wildlife Service 2625 Redwing Court Fort Collins, CO 80525 Ike Ellison, AEAM Group Peter Taylor, Information Officer	

APPENDIX D

RAW DATA: STATE LITERATURE SEARCHES

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Allred, M. 1977. Public opinion survey of fishing and hunting activities in Utah. UDWR Publication 76-22, Project FW-17-R-3, 15 Nov. 76, prepared by Bureau of Government and Opinion Research, Utah State University, Logan, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: See Tuttle (1975).

Alpentech (The Architects/Planners Alliance). 1978. A conceptual master plan for Bear Lake West. Unpublished environmental statement, prepared to meet requirements of Bear Lake Regional Commission, dated summer 1978. (ANALYZED DATA)

Location: Bear Lake Regional Commission, Fish Haven, Id.

Evaluation: Design: Contains a brief discussion of wildlife species and general habitat requirements on private and nearby public lands.

Includes a species list. Timing: 1 field reconnaissance. Analysis

Methods: No real analysis, compilation of data from field reconnaissance, interviews with USFS and Idaho Fish and Game.

Value to OIA Study: Conclusions: Concludes that little impact would occur and makes general recommendations. Baseline Data: Too qualitative to be of value. Further Study: None recommended.

Subjective Rating of Document: Value is limited by the qualitative nature of the document.

Babcock, W.H. 1977. Browse evaluation and survey techniques for the Uinta north slope moose herd. Thesis. Utah State University, Logan, Utah. (ANALYZED DATA)

Location: Utah State University Library, Logan, UT.

Evaluation: Design: Clipping samples of current and last year's willow growth were compared for nutritive value by proximate analysis, moose utilization was simulated by clipping. Aerial counts and pellet-group estimates were compared for moose survey technique. Timing: Jan. 1972 - June 1974. Analysis Methods: Analysis of variance, F tests, confidence intervals. Population estimates, mean, confidence intervals.

Value to OIA Study: Conclusions: Clipping caused nutritive increases. Nutritive value decreased with twig age. Carrying capacity of winter range was found to be larger than previously described. Aerial counts and pellet-group estimates were poorly correlated. Baseline Data: Valuable data for north slope of Uintas. Further Study: Food habits of moose should be studied and range inventory made. Pellet-group methods should not be used for population estimates without further refinements. Random stratified quadrant surveys should be designed to improve aerial estimates.

Subjective Rating of Document: Valuable information on carrying capacity of moose winter range on north slope of Uinta Mountains. Information on aerial estimation of moose population.

Badame, S. n.d. Listing of contents of 2600 wildlife files at Logan, Ogden, Mountain View, and Evanston Ranger Districts. Unpublished manuscript. Wasatch-Cache National Forest, Salt Lake City, Utah. (RAW DATA)

Location: Wasatch-Cache National Forest Supervisor's Office, Salt Lake City, Utah.

Contact Person: Jim Cole, Mark Shaw.

Evaluation: Design: Listing of contents of files. Timing: NA.

Anticipated Completion Date: completed.

Value to OIA Study: Geographic Area Covered: Logan, Ogden, Mountain View, and Evanston Ranger Districts - only latter two are significantly within the study area. Baseline Data: NA. Further Study: Contents of Mountain View and Evanston files should be examined. Potential for Use in Wildlife Management: Some items may have value, although most are small site-specific or have data collected elsewhere.

Subjective Rating of Document: The value of this manuscript is as a guide to the files rather than for its own contents.

Other Comments: Highlights - Evanston: mid-winter raptor survey 1979 and 5-year summary. Little West Blacks Fork fish barrier project photos, moose ecology progress report, Evanston RD limited wildlife management plan, prescribed burn notes, and aspen rejuvenation project notes. Mountain View: moose browse transects, elk transects, Lyman project fishery work (see U.S. Bureau of Reclamation, 1975), white-tailed ptarmigan introduction notes, riparian communities notes, and detailed notes from Winn's study 1974-1975 (see Winn 1976).

Bailey, W.J., Jr. 1963. Utah game bird harvest 1962. UDWR Departmental Information Bulletin 63-8, Project W-65-R-11, dated 1 May 63, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah and UDWR.

Evaluation: Design: Grouse (all species) hunting was studied by a questionnaire returned by 79.9% sample of hunters instructed to keep a record of hunted area, time spent and bag. A 10% sample of other upland game bird hunters were asked for the same information.

Timing: 1 year season. Analysis Methods. Extrapolated totals, percents, and averages were collected.

Value to OIA Study: Conclusions: Sage grouse were the most hunted grouse, and Rich and Summit Counties received the greatest hunting pressure. Data for other species is summarized but does not include the study area. Baseline Data: Could be used to calculate long term

trends in population, hunting patterns, etc. Further Study: recommended in the text.

Subjective Rating of Document: Provides good historical data on grouse in particular, as well as other upland game birds, but data is countywide.

Comment: Raw data is included in appendix.

Bailey, W.J., Jr. 1964. Utah upland game bird harvest 1963. UDWR Departmental Information Bulletin 64-4, Project W-65-R-12, dated 1 July 64, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah and UDWR.

Evaluation: Design: Questionnaires were sent to a 10% sample of hunters asking bag, time spent hunting, and county hunted. Includes data on pheasant, chukar, sage grouse, forest grouse, quail, Hungarian partridge, and wild turkey. Timing: 1 season. Analysis Methods: Total harvests were extrapolated. Percentages and averages were calculated and all three were compared to long term (8-16 years) data.

Value to OIA Study: Conclusions: Rich County continued to supply the greatest percentage of sage grouse, state-wide, but Summit County was fourth. Rich County was fourth in forest grouse. Baseline Data: Could be used to calculate long term trends. Further Study: None recommended.

Subjective Rating of Document: Provides good quality data on historic upland game bird harvests, but data is county-wide.

Bangerter, A. 1969. State-wide fishery management survey fish harvest inventory. UDWR Publication 69-4, Dingell-Johnson Project F-22-R-2 Job No. A-1, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah and UDWR.

Evaluation: Design: 10,000 postcard questionnaires were sent to licensed anglers (29.3% return) and used to calculate fishing pressure and harvest. See Bangerter (1969).

Bangerter, A. 1969. State-wide fishery management survey fish harvest inventory. UDWR Publication No. 69-13, Dingell-Johnson Project F-22-R-2 Job No. A-1, Salt Lake City, Utah. ANALYZED DATA.

Location: University of Utah, UDWR.

Evaluation: Design: 10,000 postcard questionnaires were sent to licensed anglers (32.4% return) and used to calculate fishing pressure and harvest. A pilot program to include unlicensed children was included. Timing: 1 year. Analysis Methods: Most data was extrapolated.

Value to OIA Study: Conclusions: Presents Data on harvest and pressure by licensed anglers, unlicensed children, and both groups combined.

Baseline Data: Data is statewide and could only be used on that basis. Further Study: None recommended.

Subjective Rating of Document: Presents useful data, assuming that the sample is representative and assumptions made in extrapolation are valid.

Bangerter, A., and D.L. Archer. 1978. State-wide fishery management survey fish harvest inventory 1977. UDWR Publication 78-13, Dingell-Johnson Project F-22-R-4, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: See Bangerter (1969).

Bartels, W. (1941). Analysis of Rocky Mountain mule deer kill records of five-year deer removal from the Logan River drainage of northern Utah.

Thesis. Utah State Agricultural College, Logan, Utah. (ANALYZED DATA)

Location: Utah State University Library, Logan, Utah.

Evaluation: Design: Average weights, antler lengths and diameters, and dentition were used to characterize harvested deer. Timing: 5 years.

Analysis Methods: Statistical tests were used to verify the validity of predicted weight tables (weight predicted by antler length and diameters).

Value to OIA Study: Conclusions: Antler diameter and length were found to be the best predictors of weight and antler diameter was found to increase uniformly with age. Fawn mortality and hunting pressure influenced the size of deer harvested. Baseline Data: Little or none, outside study area. Further Study: None recommended.

Subjective Rating of Document: Suggests valuable and simple methods to determine characteristics of antlered-only hunted herds.

Beall, D.L. 1976. Population dynamics and age determination for five Utah deer herds. Thesis. Utah State University, Logan, Utah. (ANALYZED DATA)

Location: Utah State University, Logan, Utah.

Evaluation: Design: 2 dentition methods were used to age harvested mule deer from 5 herds (2 included in study area). Survival rates were estimated from age distribution. Timing: 1972 hunting season.

Analysis Methods: Agreement rates were calculated from comparison results of age determinations. Age structures were estimated from age frequency distribution from cementum-annulation counts. Correlation coefficients were computed between rate of population change + 5 indices to population dynamics.

Value to OIA Study: Conclusions: Population parameters were determined. Adult doe survival rate was 0.55/year. All 5 herds showed negative

rates of population change. Hunting pressure was correlated to rate of population change. Baseline Data: Limited value as baseline data. Further Study: A formula could be developed to prescribe hunting seasons to get a specific harvest, by adjusting hunting pressure on doe populations. Habitat should be manipulated to enhance deer populations.

Subjective Rating of Document: Valuable techniques for management of mule deer populations. Data currently of limited value on OIA study area.

Bear Lake Regional Commission. n.d. Wildlife 1 map, Rich County, Utah. Unpublished map prepared by Bear Lake Regional Commission, Fish Haven, Idaho. (MAPPING)

Location: Bear Lake Regional Commission, Fish Haven, Idaho.

Contact Person: Craig Thomas

Type of Map: Habitat and Species Occurrence. Area Covered: Rich County, Utah. Scale: 1" = 1 mile.

Evaluation: Habitat Types Mapped: Deer winter range (upper and lower limit), deer severe winter range, elk winter areas, moose winter areas, moose summer/winter area, antelope winter areas, antelope summer/winter areas, cougar sighting areas, deer migration routes.

Resolution: Upper limit of deer winter range: 70-80 acres, lower limit of deer winter range: 15-20 acres, deer severe winter range: 5-10 acres, elk winter areas: 15-20 acres (most are 2,000+ acres), moose summer/winter areas: 250-300 acres, antelope winter areas: 30-40 acres, antelope summer/winter areas: 70-80 acres, cougar sighting areas: 3,000 acres, deer migration routes: 425-450 yards wide. Ground Truthed? Yes. Number of Seasons: unknown. Year of Original Mapping: unknown.

Subjective Evaluation of Mapping System: Useful for planning, but the resolution limits the value for impact assessment. This map also combines several UDWR maps into one.

Comments: Sources given as UDWR and BLM.

Bear Lake Regional Commission. n.d. Wildlife 2 map, Rich County, Utah. Unpublished map prepared by Bear Lake Regional Commission, Fish Haven, Idaho. (MAPPING)

Location: Bear Lake Regional Commission, Fish Haven, Idaho.

Contact Person: Craig Thomas

Type of Map: Habitat and species occurrence. Area Covered: Rich County, Utah. Scale: 1" = 1 mile.

Evaluation: Habitat Types Mapped: Stream fisheries (by UDWR class) raptor nesting areas, bald eagle roosts, osprey nest areas, potential peregrine falcon areas, turkey vulture eyries, waterfowl areas, great

blue heron rookeries, and sandhill crane areas. Resolution: Fisheries: by stream reaches of several miles, raptor nesting areas: 100-150 acres (most are 500-2,000 acres), bald eagle roosts: 70-80 acres, osprey nest areas: 200-250 acres, potential peregrine falcon areas: 100-150 acres. turkey vulture eyries: 70-80 acres, waterfowl areas: 50-20 acres, great blue heron rookeries: 70-80 acres, sandhill crane areas: 5-10 acres (most are 500-2,000 acres). Ground Truthed? Yes. Number of Seasons: unknown. Year of Original Mapping: unknown.

Subjective Evaluation of Mapping System: Useful for planning, but the value for impact assessment is limited by the resolution. This map also combines several UDWR maps into one.

Comments: Sources given as UDWR and BLM.

Bear Lake Regional Commission. n.d. Wildlife 3 map, Rich County, Utah. Unpublished map prepared by Bear Lake Regional Commission, Fish Haven, Idaho. (MAPPING)

Location: Bear Lake Regional Commission, Fish Haven, Idaho.

Contact Person: Craig Thomas

Type of Map: Habitat and Species Occurrence. Area Covered: Rich County, Utah. Scale: 1" = 1 mile.

Evaluation: Habitat Types Mapped: Prairie dog towns, potential black-footed ferret area, sage grouse wintering, and sage grouse strutting areas. Resolution: Prairie dog towns: 30-40 acres, potential black-footed ferret areas: 70-80 acres, snowshoe hare: 50-100 acres, chukar: 700-800 acres, Hungarian partridge: 1100-1200 acres, ring-necked pheasant: 5-10 acres, ruffed and blue grouse: 70-80 acres, sage grouse wintering: 45-50 acres, sage grouse strutting: 450-550 acres. Species Included: Snowshoe hare, chukar, Hungarian partridge, ring-necked pheasant, and ruffed and blue grouse. Ground Truthed? Yes. Number of Seasons: unknown. Year of Original Mapping: unknown.

Subjective Evaluation of Mapping System: Useful for planning, but the value for impact assessment is limited by the resolution. This map also combines several UDWR maps into one.

Comments: Sources given as UDWR and BLM. Only one potential black-footed ferret area is mapped, which is near Neponset Reservoir.

Bear Lake Regional Commission. 1979. Wildlife 1 map, Bear Lake County, Idaho. Unpublished map prepared by Bear Lake Regional Commission, Fish Haven, Idaho, dated June 1979. (MAPPING)

Location: Bear Lake Regional Commission, Fish Haven, Idaho.

Contact Person: Craig Thomas

Type of Map: Habitat and Species Occurrence. Area Covered: Bear Lake County, Idaho. Scale: 1" = 1 mile.

Evaluation: Habitat Types Mapped: Big game winter range, important elk habitat, elk calving areas, moose winter range and calving areas, elk migration routes, and deer migration routes. Resolution: Big game winter range: 30-40 acres, important elk habitat: 70-80 acres, elk calving areas: 70-80 acres, moose winter range: 30-40 acres, elk migration routes: 850-900 yards wide, deer migration routes: 425-450 yards wide. Ground Truthed? unknown. Year of Original Mapping: unknown.

Subjective Evaluation of Mapping System: Useful for planning, but the resolution is not suitable for impact assessment.

Comments: Source given as Idaho Dept. of Fish and Game. The original sepi is not available.

Bear Lake Regional Commission. 1979. Wildlife 2 map, Bear Lake County, Idaho. Unpublished map prepared by Bear Lake Regional Commission, Fish Haven, Idaho, dated June 1979. (MAPPING)

Location: Bear Lake Regional Commission, Fish Haven, Idaho.

Contact Person: Craig Thomas

Type of Map: Habitat and Species Occurrence. Area Covered: Bear Lake County, Idaho. Scale: 1" = 1 mile.

Evaluation: Habitat Types Mapped: Hungarian partridge and mourning dove, sage and sharp-tailed grouse, sage grouse leks, potential leks, crucial sage grouse wintering, and chukar. Resolution: Hungarian partridge and mourning dove: 100-1200 acres, sage and sharp-tailed grouse: 70-80 acres, sage grouse leks: 15-20 acres, potential leks: 200-250 acres, crucial sage grouse wintering: 450-550 acres, chukar: 100-150 acres. Year of Original Mapping: unknown.

Subjective Evaluation of Mapping System: Useful for planning, but the resolution is not suitable for impact assessment.

Comments: Source given as Idaho Dept. of Fish and Game. The original sepi is available.

Bear Lake Regional Commission. 1979. Wildlife 3 map, Bear Lake County, Idaho. Unpublished map prepared by Bear Lake Regional Commission, Fish Haven, Idaho, dated June 1979. (MAPPING)

Location: Bear Lake Regional Commission, Fish Haven, Idaho.

Contact Person: Craig Thomas

Type of Map: Habitat. Area Covered: Bear Lake County, Idaho. Scale: 1" = 1 mile.

Evaluation: Habitat Types Mapped: Stream fishing class (1-4), waterfowl areas, crucial waterfowl areas, forest (blue and ruffed) grouse areas, area of known occurrence: merlin, ferruginous hawks, bald eagle,

osprey, trumpeter swan, peregrine, gyrfalcon (all mapped as one polygon along east shore of Bear Lake). Resolution: stream class: entire stream, waterfowl areas: 30-40 acres, crucial waterfowl areas: 30-40 acres, forest grouse: 100-150 acres, area of known occurrence: 700-800 acres. Ground Truthed? unknown.

Subjective Rating of Mapping System: Useful for planning, but the resolution is suitable for impact assessment.

Comments: Source given as Idaho Dept. of Fish and Game. The original sepia is available.

Bingham Engineering. 1982. Blue Ridge environmental impact statement (revised) and vicinity plan for Sticking Mayflower Fonds and Sticking Mayflower Recreational Fonds. Unpublished, prepared to meet requirements of Summit County Planning Dept., dated March 82. (ANALYZED DATA)

Location: Summit County Planning Dept., Coalville.

Evaluation: Design: Qualitative discussion of mammals, birds, threatened and endangered species, and fish found on site and environmental impacts of development. Includes 11 pages of tables of seasonal status, cover types used, elevations used, nesting habitat, and abundance of birds from US Bureau of Reclamation (1975) Environmental Assessment. Weber Basin Project, Water Sales contracts, East Canyon-Parleys Park, Snyderville Basin Project, dated Mar 75. Timing: unspecified. Analysis Methods: qualitative.

Value to OIA Study: Conclusions: Habitat loss would occur and human populations would degrade surrounding habitats. Baseline Data: too qualitative to be of value. Further Study: none recommended.

Subjective Rating of Document: Too qualitative to be of much value, but the habitat matrix could be useful.

Braun, C.E., T. Britt, and R.O. Wallestad. 1977. Guidelines for maintenance of sage grouse habitats. The Wildlife Society Bulletin 5:3 (Published version of Western Sage Grouse Committee. 1974. Guidelines for habitat protection in sage grouse range.) (ANALYZED DATA)

Location: BLM, Salt Lake City District, Salt Lake City, Utah.

Evaluation: Design: Guidelines are based on a literature review.

Timing: unknown. Analysis Methods: qualitative.

Value to OIA Study: Conclusions: Recommendations are made for environmental documentation and planning, areas to be treated, treatment pattern, and degree of kill. Baseline Data: No value. Further Study: It may be worthwhile to verify the validity of the recommendations on a site specific basis.

Subjective Rating of Document: Presents some worthwhile recommendations and contains a concise literature review.

Cherry, J. 1981. Memorandum to Jack Peterson, Salt Lake City, Utah. County Spray Project/Sage Grouse Conclusions, dated 27 March 81, File designation 0640 (U-201). (ANALYZED DATA)

Location: BLM Files, Salt Lake District. Contact Jack Brown or Cal McCluskey.

Brown, J., and C. McCluskey. 1982. Randolph habitat management plan VT-020-WHA-7-2. Unpublished draft prepared by BLM, Salt Lake District. Salt Lake City, Utah. (ANALYZED DATA)

Location: BLM, Salt Lake District, Salt Lake City, Utah.

Evaluation: Design: Includes a qualitative discussion of the species present, more detailed discussions of sage grouse, deer fences, and riparian areas and specific plans to meet the objectives in the Randolph MFP including monitoring, costs, and manpower needs. Timing: unknown. Analysis Methods: Largely qualitative, some averages and percents.

Value to OIA Study: Conclusions: Conclusions are recognition of management needs reflected in project plans. Some plans are directly related to oil and gas operations, particularly seismic exploration.

Baseline Data: No value. Further Study: Monitoring plans in the document incorporate further study.

Subjective Rating of Document: The major value of this document is to show BLM's direction in wildlife management on a site-specific basis.

Bunnel, S.D., and J.P. Leatham. 1980. Utah upland game annual report 1979. UDWR Publication 80-7, Project W-65-R-28, Job A-4, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: See UDWR (1965).

Bunnel, S.D., and D.W. Olsen. 1978. Utah upland game annual report 1977. UDWR Publication 78-8, Project W-65-R-D-25, Job A-4, Salt Lake City, Utah. (ANALYZED DATA)

Location:: University of Utah, UDWR.

Evaluation: See UDWR (1965).

Burruss, J.S. 1978. Utah black bear harvest 1977-78. UDWR Publication 78-11, Project W-65-R-D-26, Job A-7, dated Sept. 78. Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: See Hillard (1976).

Burruss, J.S. 1980. Utah cougar harvest 1978-79. UDWR Publication 79-9. Project W-65-R-D-27, Job A-7, dated Jan. 80, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: See Fair (1977).

Burruss, J.S. 1980. Utah black bear harvest 1978-79. UDWR Publication 79-10, Project W-65-R-D-27, Job A-7, dated Feb. 80. Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.
 Evaluation: See Hillard (1976).

Burruss, J.S. 1980. Utah black bear harvest 1979-80. UDWR Publication 80-18. Project W-65-R-D-28, Job A-7, dated Sept 80, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.
 Evaluation: See Fair (1976).

Bush and Gudgeon, Inc. n.d. Flinders Ranch a planned unit subdivision and Flinders Leisure Business Park environmental impact statement. Unpublished, prepared for Judd Flinders to meet requirements of Summit County Planning Dept. (ANALYZED DATA)

Location: Summit County Planning Dept., Coalville.

Evaluation: Design: Qualitative and very brief discussion of habitats, species present, and impacts of development. Timing: unspecified.

Analysis Methods: qualitative.

Value to OIA Study: Conclusions: Would cause habitat loss on developed portion of the property. Baseline Data: no value. Further Study: none recommended.

Subjective Rating of Document: Too qualitative and brief to be of value.

Campbell, L.B., and C.A. Locay, 1982. Soil Survey of Rich County, Utah. National Cooperative Soil Survey, issued July 1982. (ANALYZED DATA)

Location: U.S. Soil Conservation Service, Logan, VT.

Evaluation: Design: Standard SCS soil survey including text and tables presenting data on wildlife habitat capabilities of soils. Timing: 4 years of field work. Analysis Methods: Standard SCS methods.

Value to OIA Study: Conclusions: Most soils receive fair to poor ratings. Baseline Data: Limited value, soil types are unlikely to change. Further Study: None recommended.

Subjective Rating of Document: Valuable for identifying limitations of soils and guiding mitigation projects.

Cherry, S. 1981. Memorandum to Jack Brown, Subject: Rich County Sage Grouse Study, dated 22 June 81, File designation 6640 (U-201). Also: Brown, J. 1981. Memorandum to Jack Peterson, Subject: Brief Summary of the Rich County Sage Grouse Studies - FY 79 and 80, dated 27 March 81, File designation 6640 (U-201). Also: Brown, J. 1981 memorandum to Jack Peterson, Subject: Rich County Spray Project/Sage Grouse Conclusions, dated 27 March 81, File designation 6640 (U-201). (ANALYZED DATA)

Location: BLM files, Salt Lake District. Contact Jack Brown or Cal McCluskey.

Evaluation: Design: Varied by year. Biased by roads and land ownership patterns. Timing: Two summers, 4 and 2 months, no other seasons studied. Analysis Methods: T-test and stepwise multiple regressions. Validity questionable due to sample sizes and biased data collection.-
 Value to OIA Study: Conclusions: Limited values for habitat characteristics, no value for disturbance. Baseline Data: Limited value for sage grouse densities, vegetational habitat composition, and relationship to water. Further Study: Could be used to design a new study, but little or no other value for further work.
 Subjective Rating of Document: Limited usefulness, outlined in detail by Cherry. Table in Cherry and both Brown memos outline findings regarding habitats used by grouse.
 Comment: Additional raw data in field notes.

Christenson, E.M. and J.D. Brotherson. 1972. Part 1 preliminary botanical survey of the Bonneville Unit of the Central Utah project. Unpublished report, prepared by the Center for Health and Environmental Studies and the Dept. of Botany, Brigham Young University, Provo, Utah, dated July 1972. (RAW DATA).

Location: U.S. Bureau of Reclamation, Provo, VT.
 Contact Person: Bob Christensen.
 Evaluation: Design: Includes a checklist of riparian and meadow vegetation at Jordanelle Reservoir site (and others outside study area) in Summit County. Also includes brief history of vegetational change in the area. Timing: 6 weeks. Anticipated Completion Date: completed.
 Value to OIA Study: Geographic Area Covered: Jordanelle Reservoir site, Summit County. Baseline Data: Repeatable, but useful only at the site. Further Study: none recommended. Potential for Use in Wildlife Management: Very little, likelihood of future impacts from oil and gas at the reservoir site is low, main value is as background.
 Subjective Rating of Document: The value is limited largely to a single site in Summit County.

Christiansen, J.E., and J.B. Low. 1970. Water requirements of waterfowl marshlands in northern Utah. UDWR Publication 69-12, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.
 Evaluation: Design: Water use of a marsh was calculated by obtaining evapotranspiration data from inflow-outflow data. Salt tolerance of various species was also studied. Timing: 3 years. Analysis Methods: Percentages and averages of data were used to develop

formulae for evapotranspiration, water requirement (seasonal and monthly) and salinity factor.

Value to OIA Study: Conclusions: A number of recommendations on water regulation, flow patterns, water levels, salinity management, and vegetation management through water management are included. Baseline Data: Little or none - outside study area. Further Study: none recommended.

Subjective Rating of Document: This document is aimed primarily at management of brackish marshes and has little value to the OIA study.

Chrostowski, H., and G.G. Williams. 1970. Wildlife management fisheries inventory North slope Uintas comprehensive study areas. Unpublished draft report, dated 31 March 71, prepared by Wasatch-Cache National Forest, Salt Lake City, Utah. (ANALYZED DATA)

Location: Wasatch-Cache N.F. Supervisor's Office, Salt Lake City.

Evaluation: Design: Qualitative surveys of lakes and streams (raw data in appendices) is summarized and discussed with history of use and current management problems and trends. Timing: single surveys over several seasons. Analysis Methods: Qualitative.

Value to OIA Study: Conclusions: A "Suggested Management Coordination Direction" section is included. Baseline Data: appended data could be used for baseline in a rough sense as quantitative guidelines were used to make qualitative assessments. Further Study: None recommended.

Subjective Rating of Document: Could be useful for comparison with new stream and lake survey data.

Cole, J., personal communication. North slope Uintas elk study. (RAW DATA)

Contact Person: Jim Cole

Evaluation: Design: Telemetry study of about 20 collared cow elk to determine seasonal ranges and migration routes. Timing: on-going. Anticipated Completion Date: unknown.

Value to OIA Study: Geographic Area Covered: North slope Uinta mountains. Baseline Data: Will provide repeatable data on seasonal ranges and migration routes. Further Study: none recommended at this time. Potential For Use in Wildlife Management: Could be very useful for elk management.

Subjective Rating of Document: NA

Other Comments: nothing written yet.

Coles, F.H. and J.C. Pederson. 1967. Big game range inventory 1965-1966. UDWR Departmental Information Bulletin 67-1, Project W-65-R-14, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Winter range and migration routes are determined by ground observations and aerial reconnaissance. Vegetation data was collected using line intercept and rectangular plot methods. Timing:- Winter ranges: unknown and varied. Vegetation: 1 season. Analysis Methods: Normal upper limits, severe upper limits, and lower limits of winter ranges are mapped. Percent cover, plants/acre, pounds of forage/acre, and total forage in the unit are calculated for each important plant species or species group.

Value to OIA Study: Conclusions: Not specifically applicable to study area, includes data for deer herd units 22 (Lakefork), 23A (Avintaquin), 26 (Vernal), 27A (Minnie Maud), 27B (Range Creek), 28A (North Book Cliffs) and 28B (South Book Cliffs). Baseline Data: Not in study area. Further Study: None recommended.

Subjective Rating of Document: Value to OIA is limited because these units are not in the study area.

Coles, F.H. and J.C. Pederson, 1968. Big game range inventory, 1966-67. UDWR Departmental Information Bulletin 68-2, Project W-65-R-15, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: See Coles and Pederson (1967).

Collins, W.B. 1977. Diet composition and activities of elk on different habitat segments in the lodgepole pine type, Uinta Mountains, Utah. UDWR Publication 77-18, Project W-105-R-D-14, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Seven tame elk were observed for 6 periods of 24 hours to determine diet and habitat preferences. Timing: 1008 elk-hours of observation. Analysis Methods: Percents and species' dry weights were calculated.

Value to OIA Study: Conclusions: Meadows, clearcuts, and revegetated roads were preferred grazing habitat; wet meadows, revegetated roads, and mature forest were preferred for other activities. Forbs were most used, followed by grasses, sedges, browse, and mushrooms. Baseline Data: No value. Further Study: None recommended.

Subjective Rating of Document: The data presented are interesting, but the representative nature and learned preferences of the study animals are open to question.

Dalton, L.B. N.D. Impacts on wildlife from energy related growth and other development. Unpublished manuscript, Utah Division of Wildlife Resources, Price, Utah. (ANALYZED DATA)

Location: UDWR, Salt Lake City

Evaluation: Design: Qualitative review of impacts on wildlife from coal, oil, uranium, and support facilities, supported by a few statistics. Timing: NA. Analysis Methods: qualitative.

Value to OIA Study: Conclusions: Conclude that conflicts exist, other conclusions are of questionable value due to poor documentation and broad generalizing. Baseline Data: no value. Further Study: none recommended.

Subjective Rating of Document: This paper is poorly documented and the descriptions of oil and gas development are not at all representative of operations in the overthrust area. The value of the report is limited.

Deschamp, J.A. 1977. Forage preferences of mule deer in the lodgepole pine ecosystem, Ashley National Forest, Utah. UDWR Publication 77-16, Project W-105-R-D-14. Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: 5 tame and trained mule deer were observed to determine their diet and habitats used. Timing: 1 season.

Analysis Methods: Percents and averages were calculated.

Value to OIA Study: Conclusions: Forbs made up 90% of the diet in non-forested areas and 65% in forests. Vaccinium scoparium was the most preferred browse species. Feeding areas in order of importance: clearcuts, meadow, mature forest, stagnated forest. Baseline Data: No value. Further Study: none recommended.

Subjective Rating of Document: Presents interesting data, but leaves unanswered questions about learned preferences of the study animals.

Draney, V.J. 1957. Utah furbearers 1956-1957. UDWR Departmental Information Bulletin No. 32, Project W-65-R-5, Job C-1 and C-2, dated 1 Aug. 1957.

Location: University of Utah, UDWR

Evaluation: Design: Beaver numbers (understocked, properly stocked, or overstocked) are given for drainages within 50 management units, and removals from 1953-1957 are tabulated by drainage and county. Recommended and actual harvests of muskrat are tabulated for wildlife refuges. Muskrats and mink trapped are broken down by county based on questionnaire. Timing: 1 season. Analysis Methods: Total and averages are calculated.

Value to OIA Study: Conclusions: Recommends extending beaver season, and initiating aerial surveys. Recommends continuance of muskrat trapping season and initiation of an aerial census. Also recommends opening marten season, although no data is presented. Baseline Data: Could be used to calculate long term trends. Further Study: None recommended.

Subjective Rating of Document: Provides useable data on historic furbearers numbers and harvest.

Duff, D.A. 1978. Riparian habitat recovery on Big Creek, Rich County, Utah - a summary of 8 years of study. Paper presented at Forum - Grazing and Riparian/Stream Ecosystems. Trout Unlimited, Inc. (ANALYZED DATA)

Location: BLM, Salt Lake City District, Salt Lake City, Utah.

Evaluation: Design: A livestock exclosure for 3,300 feet of stream was constructed and riparian vegetation, water quality, fines in the streambottom, fish production and bird and mammal use were monitored as recovery progressed and after trespass grazing. Timing: 8 years, ongoing. Analysis Methods: percents and averages were calculated.

Value to OIA Study: Conclusions: Riparian vegetation increased 63 percent in 4 years and was removed entirely by 6 weeks of trespass grazing, no change was recorded in streambottom fines, fish populations increased 360% after 3 years and 570% after 7 years, and bird and mammal use increased 350% in 9 years. Baseline Data: Little value due to the small size of the area studied. Further Study: The results should be verified on other streams and compared with impacts resulting from oil and gas developments.

Subjective Rating of Document: Very valuable as a concise summary of the effects of grazing on riparian habitat in the study area.

Erman, D.C. 1969. Ordination of benthic invertebrate communities in Bear Lake. Dissertation. Utah State University. (ANALYZED DATA)

Location: Utah State University Library, Logan, UT.

Evaluation: Design: Ordination methods were used to examine environmental relationships and benthic invertebrate community structure in the littoral zone of Bear Lake. Timing: Summer and fall 1967. Analysis Methods: Means of O₂ consumption and benthic invertebrate body lengths, correlation coefficients between environmental factors, Orloci and Bray - Curtis ordination, relative importance values, comparisons made using relative efficiencies and multiple correlations.

Value to OIA Study: Conclusions: Two ordination effects of different quantitative species data (importance values) were compared. A new importance value was developed based on O₂ consumption, comparison of O₂ importance value with density times the square root of frequency showed differences in relative importance of the species. Ordinations showed significant relationships between ordination axes, chironomid species, and environmental factors. Areas near human development were more eutrophic than undisturbed areas. Baseline Data: Valuable for studies of Bear Lake. Lists of invertebrate

species and their O₂ consumption. Further Study: This paper's techniques could be used for background if studies of Bear Lake are undertaken.

Subjective Rating of Document: Limited management value for Bear Lake. Data on human development impacts on benthic invertebrate communities.

Eyre, L. and D. Paul. 1973. Raptors of Utah. UDWR Publication No. 73-7. Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Background information on raptors in general, species list, and field marks, life history, distribution, and comments on each species. Timing: unknown. Analysis Methods: qualitative.

Value to OIA Study: Conclusions: Few, if any, conclusions of value to OIA. Baseline Data: no value. Further Study: none recommended.

Subjective Rating of Document: Background for the layman, but no value to OIA.

Fair, J.S. 1977. Utah black bear harvest 1976-77. UDWR Publication 79-9, Project W-65-R-D-25, Job A-7, dated Sept. 77, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: See Hilliard (1976)

Fair, J.S. 1977. Utah cougar harvest 1976-77. UDWR Publication 77-10, Project W-65-R-D-25, Job A-7, dated Sept. 77, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: Design: Includes a summary of cougar management in Utah, a summary of depredation harvest, 1976 harvest and hunter days by deer herd unit, and cougars treed by pursuit permittees by deer herd units. Data is from permit postcards. Timing: 1 season. Analysis Methods: totals are given.

Value to OIA Study: Conclusions: Given as harvest recommendations. Baseline Data: Some value on deer herd unit-wide basis. Further Study: none recommended.

Subjective Rating of Document: Provides some useful information, but limited by the scope of the data.

Fierro G., L.C. 1977. Influence of livestock grazing on the regrowth of crested wheatgrass for winter use by mule deer. UDWR Publication 77-17, Project W-105-R-D-14, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: The influence of heavy grazing on growth available for deer use was examined by range analysis, nutritional value was determined by lab tests, digestibility was determined by in-vivo tests using mule deer, and use by wild deer was determined by micro-histological analysis of pellets. Timing: 2 years. Analysis Methods: Percentages, averages, and levels of significance were calculated.

Value to OIA Study: Conclusions: The nutritional quality of winter crested wheatgrass was superior to most browse species. The grass was very digestible and it was used by deer in early fall and spring.

Baseline Data: Little or no value. Further Study: This study should be followed up in the OIA study area, and the question of why wild deer did not eat wheatgrass in winter should be further examined.

Subjective Rating of Document: Presents some data that could be very useful for reclamation planning.

Fitzgerald, J.W. 1982. Utah black bear harvest 1981-82. UDWR Publication 82-1, Project W-69-R-D-30, Job A-7, dated May 82, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: See Hillard (1976).

Follis, T.B. 1972. Reproduction and hematology of the Cache elk herd. UDWR Publication 72-8, Salt Lake City, Utah (Also: Dissertation. Utah State University, Logan, Utah). (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Pregnancy rates of cows were correlated with pre-and post-season cow/calf ratios, efficiency of yearling and adults males was studied, twinning was induced by hormone implants, and a full spectrum of serological tests were performed in captive and free elk. Timing: 4 years. Analysis Methods: percents, averages, and levels of significance were calculated.

Value to OIA Study: Conclusions: Adult and yearling males were similarly efficient in impregnating laws, twinning attempts met with mixed success, and some differences were found in sevology between free and captive elk. Baseline Data: Value is limited to veterinary background. Further Study: none recommended.

Subjective Rating of Document: The main value of this document is for veterinary background and use in experimental manipulations.

Gates, J.F., and A.F. Regenthal. 1964. Lakes of the high Uintas Ashley Creek, Burnt Fork Creek, Sheep Creek-Carter Creek, and Whiterocks River

drainages. UDWR Publication 64-8, Revision No. 1., Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Acreage, depth, access, fish species present, and qualitative assessment of fishing quality and pressure are presented for lakes. Timing: unknown. Analysis Methods: unknown.

Value to OIA Study: Conclusion: see design. Baseline Data: Too qualitative to be of value. Further Study: none recommended.

Subjective Ratings of Documents: Provides qualitative data that may be useful for planning.

Comment: This publication is being updated.

Gates, J.F., and A.F. Regenthal. 1964. Lakes of the high Uintas Beaver Creek, Henry's Fork-Smiths Fork, Black Fork, and Bear River Drainages Publication 64-9 Revision No. 1, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah and UDWR.

Evaluation: See Gates and Regenthal (1964).

Geer, W.H. N.D. Evaluation of five instream flow needs methodologies and water quantity needs of three Utah trout streams. Unpublished report. Cooperative agreement 14-16-0006-78-905, USFWS and UDWR. (ANALYZED DATA)

Location: University of Utah, UDRW.

Evaluation: Design: Compares: Utah Water Records, Utah Water Yields, Modified Sag-tape, USFS Region 4, and USFWS Instream Flow Group methods in terms of application, analysis, and data needs. Timing: NA. Analysis Methods: Qualitative.

Value to OIA Study: Conclusions: Appropriate methods would depend on stream characteristics, time and money available, data available, and resolution desired. Baseline Data: No value. Further Study: None recommended.

Subjective Rating of Document: Useful for selecting instream flow needs analysis method.

Giunta, B.C. 1979. Big game range inventory 1977. UDWR Publication 79-3, Project W-65-R-D-26 Job A-6, dated March 1979, Salt Lake City, Utah. (ANALYZED DATA).

Location: University of Utah, UDWR.

Evaluation: See Coles and Pederson (1967)

Value to OIA Study: Baseline Data: Provides valuable data for deer herd unit 19 (Coalville) and 20 (Kamas). See Figure D-1.

Subjective Rating of Document: Provides valuable data for two deer herds in the study area.

Greenhalgh, C.M., 1962. Utah game bird harvest 1961. UDWR Departmental Infor-

mation Bulletin 62-2, Project W-65-R-10, dated 1 May 62, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: Design: Most data presented is for pheasant. 10% of upland game bird hunters were sent surveys asking for pressure and success data for all species. A sample of pheasants were aged in the field by spur measurements. Timing: 1 season. Analysis

Methods: Average success and pressure were calculated for several counties (not in study area) and are compared with long term (10 year) data for pheasant, chukar, sage grouse, and quail. Shorter period comparison for Hungarian partridge does not include the study area.

Value to OIA Study: Conclusion: Rich and Summit Counties had less than 1% of the state wide pheasant harvest and pressure from 1952-1961. Summit County had a higher than average chukar success rate throughout the 10 year period. Baseline Data: Could be used to calculate long term trends (1952-1961 presented) from 1952 to present. Further Study: none recommended.

Subjective Rating of Document: Provides good data, although much does not include the study area and the value of sage grouse data is limited.

Comment: Sage grouse data is presented by undefined "areas", limiting the value of the data.

Hancock, N.V. 1955. A management study of the Cache elk herd. Thesis. Utah State Agricultural College, Logan, Utah. Also published by UDWR. (ANALYZED DATA)

Location: Utah State University Library, Logan; University of Utah Library (Western Americana Collection - closed stock); also in UDWR Big Game Book.

Evaluation: Design: Population data is based on aerial counts, ground counts, Lincoln index, and life equations. Migration routes are based on aerial and ground observations. Timing: Data is given for two winters and one summer. Analysis Methods: See design. Supplemental winter feeding evaluation is based on comparison of mortality between fed and control groups.

Value to OIA Study: Conclusions: Most valuable conclusions to OIA are population winter/summer ranges, and migration routes. Author concludes that much remains to be learned about Cache elk herd. Baseline Data: Good quality historical baseline data on population numbers and migration routes. Further Study: see other UDWR reports.

Subjective Rating of Document: Valuable for historic baseline data and identification of historic critical/sensitive areas adjacent to the overthrust belt.

Comments: Part of study area is in Rich County (western 1/3 of county) but most work was peripheral to the OIA area. Herd history from reintroduction to 1954 is briefly discussed.

Type of Map: Species Distribution

Scale: 1/4" = 1 mile.

Evaluation: Resolution: Summer and winter ranges 500-600 acres.

Major and minor migration routes are indicated by different sized arrows. Ground Truthed? Yes. Number of Seasons: 2 winters, 1 summer. Distribution From Field Surveys. Year of Original Mapping: 1954. Years Updated: none. Number of Years of Data: 2.

Subjective Evaluation of Mapping System: Some value for assessing changes in migration routes and seasonal ranges.

Comments: Winter range is based on two winters' data, summer range is based on 1 summer's data.

Hart, C.M., et al. 1950. The sharp-tailed grouse in Utah its life history, status, and management. UDWR Publication No. 3, dated 14 Sept. 50, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Includes literature review of life history, food habits by fecal examination. Timing: unclear. Analysis Methods: percents, averages, and rankings.

Value to OIA Study: Conclusions: Concludes that abundance and ranges have declined, probably due to cultivation, improper grazing, and burning. Baseline Data: Little or no value. Further Study: none recommended.

Subjective Rating of Document: The value of this document is limited by its age.

Hayward, C.L. (1972). Birds and mammals of the Bonneville Unit of the Central Utah Project. Unpublished, prepared by Center for Health and Environmental Studies and Zoology Department, BYU dated July 1972. (RAW DATA)

Location: U.S. Bureau of Reclamation, Provo, Utah.

Contact Person: Bob Christensen.

Evaluation: Design: Qualitative discussion of bird and mammal status and checklists are presented. Timing: 6 weeks. Anticipated Completion Date: NA.

Value to OIA Study: Geographic Area Covered: Jordanelle Reservoir site, and other areas outside study area. Baseline Data: Not repeatable, literature compilation. Further Study: None recommended. Potential For Use in Wildlife Management: Very qualitative nature severely limits the usefulness of this document.

Subjective Rating of Document: see above.

Hennessy, S.P. 1978. Ecological relationships of accipiters in northern Utah - with special emphasis on the effects of human disturbance. Thesis. Utah State University, Logan, Utah. (ANALYZED DATA)

Location: Utah State University Library (special collections), Logan, UT.

Evaluation: Design: Examination of effects of habitat parameters and human disturbance on nesting success of goshawks, cooper's and sharp-shinned hawks. Active hawk nests were located with recorded calls, then listed by human disturbance category. 15 x 25 m vegetation plots were done at each nest. Pesticide analysis for eggshell thickness. Nest success determined. Timing: 1973 - 1974.

Analysis Methods: Sample means, standard deviations, discriminant function analysis, principal components analysis, factor analysis. correlation matrix and canonical correlation analysis. Multiple regression analysis.

Value to OIA Study: Conclusions: Accipiters tend to nest in large trees, near openings, roads or trails, and near water. These habits increase the probability of human disturbance. Detailed habitat information given for 32 nests in northern Utah (includes Rich Co.) and southern Idaho (Franklin Co.). Food-begging calls were sometimes successful for attracting adult birds. Human disturbance was a cause of unsuccessful nesting. DDT residues were found in eggshells.

Baseline Data: Valuable information on nesting habitat. Further Study: Research should be used in planning recreation areas, roads, timber cuttings, and other human disturbances.

Subjective Rating of Document: Valuable information on acciptier habitat use, effects of human disturbance.

Hickman, G.L. 1971. The Coalville deer herd in northwestern Utah: its ecology and management. Thesis. Utah State University, Logan Utah. (ANALYZED DATA)

Location: Fisheries and Wildlife Department (F&W Coop Unit Section), Utah State University, Logan, UT

Evaluation: Design: Harvested deer from the Coalville management herd (Summit Co., UT) were characterized by: sex and age ratios from extensive field observations, and sex, age, and location of kill records from Chalk Creek checking station. Physical condition was determined by bone marrow tests, relative amount of visible body fat, weights by sex and age class, and antler measurements. Age classes were determined by tooth replacement and wear. Timing: September 1964 - May 1966. Analysis Methods: Sex and age ratios, mortality rates were calculated. Regression analyses and statistical tests were used to validate predicted age tables (age predicted) by antler lengths,

diameters, and points, and based on initial weight to age correlation).

Value to OIA Study: Conclusions: Male deer weights, antler points, length of main beam, and antler diameter could be used for aging criteria (increase with age). In contrast female weights increase until they reached 2.5 years of age, with no significant gains thereafter. Antler diameter was considered a good indicator of physical condition. Deer hunting regulations should be based on the winter range condition on the majority of winter range concentration areas. Tag returns did not indicate differential movement of sex and age classes from winter concentration areas to the summer ranges. Snow depth triggered fall migration, while new vegetation controlled the spring upward movement. Baseline Data: Valuable baseline information for mule deer management on OIA study area. Further Study: None recommended.

Subjective Rating of Document: Suggests valuable methods to determine characteristics of antlered-only hunted herds. Valuable management recommendations for mule deer.

Hilliard, M.A. 1976. Utah black bear harvest 1975-1976. UDWR Publication 76-12, Project No. W-65-R-D-24, Job A-7, dated July 76. Salt Lake City, Utah.

Location: University of Utah, UDWR

Evaluation: Design: Includes a history of black bear management in Utah, a 10 season summary of regular and depredation/damage barriers, 1975 harvest by deer unit, hunter days by deer herd unit and month of season, bears treed by pursuit permittees by deer units, 9 year summary of bears taken by deer herd units and number of bears taken statewide 1916-1975. Data from permit post cards. Timing: varies. Analysis Methods: totals are given.

Value to OIA Study: Conclusions: Given as harvest recommendations.

Baseline Data: The value is limited to county-wide and deer herd unit-wide data. Further Study: none recommended.

Subjective Rating of Document: Provides some useful information on black bear, particularly historical perspective, but the value of data is limited by its scope.

Hrostowski and Williams (1970): see Chrostowski and Williams (1970), spelling uncertain.

James Webster Associates, Inc. 1980. Initial phase - industrial zone Silver Creek Community Summit County, Utah, environmental impact statement. Unpublished, prepared to meet requirements of Summit County Planning Dept. dated Jan. 80. ANALYZED DATA

Location: Summit County Planning Dept., Coalville.
 Evaluation: Design: Very brief and qualitative description of wild-
 life present and possibility of rare or endangered species occur-
 rence. Timing: unspecified. Analysis Methods: qualitative.-
 Value to OIA Study: Conclusions: Development would disturb habitat.
 Baseline Data: no value. Further Study: none recommended.
 Subjective Rating of Document: Too brief and qualitative to be of
 value.

Jenkins, M.A. 1981. Memo, subject: color marked bald eagles. Unpublished
 memo, USFWS, Denver Wildlife Research Center, Denver, Colorado. RAW DATA
 Location: BLM, Utah State Office, Salt Lake City.
 Contact Person: Jerry Farringer.
 Evaluation: Design: Describes wing markers and bands placed on nest-
 ling and wintering bald eagles in Wyoming. Timing: NA. Antici-
 pated Completion Date: unknown.
 Value to OIA Study: Geographic Area Covered: NA. Baseline Data:
 NA. Further Study: underway. Potential For Use in Wildlife
 Management: Could provide valuable data on areas used by bald eagle
 and migration routes.
 Subjective Rating of Document: The results of the study will be much
 more valuable than this document.

Jensen, F.C. 1972. Utah furbearers harvest report and management recommenda-
 tions 1971-1972. UDWR Publication 72-13, Project W-65-5-20 dated Sept 72,
 Salt Lake City, Utah. (ANALYZED DATA)
 Location: University of Utah, UDWR.
 Evaluation: See John (1969).

Jobman, W.G. and M.E. Anderson. 1981. Potential present range of the black-
 footed ferret as of January 1, 1981. Unpublished report prepared by USFWS,
 Pierre, South Dakota, dated Aug 81. (ANALYZED DATA)
 Location: USFWS Endangered Species Office, Salt Lake City, Utah.
 Evaluation: Design: Survey questionnaire was mailed to 62 federal,
 state, provincial and private offices in the U.S. and Canada. Con-
 firmed and probable sightings are separated. Timing: 11 years (1
 Jan 70 to 1 Jan 81). Analysis Methods: Reported sightings are
 tabulated and plotted on maps.
 Value to OIA Study: Conclusions: Some changes in the known range of
 the species have been documented. An increase in the number of con-
 firmed sightings since 1977 is attributed to increased survey efforts.
 Baseline Data: Little or no value. Further Study:

Continued updating of this compilation of sightings could be valuable for planning.

Subjective Rating of Document: The primary value of this document is as a compilation of ferret sightings throughout its range.

Type of Map: Species Distribution

Area Covered: Parts of Idaho, Montana, North and South Dakota, Wyoming, Nebraska, Utah, Colorado, Kansas, Arizona, New Mexico, Texas, Oklahoma, Alberta, and Saskatchewan (their figure 13). Other figures have confirmed and probable sightings on state maps showing counties: Utah (their figure 11), 1 inch = 59 miles, 7 sightings; Wyoming (their figure 12), no scale, 75 sightings.

Evaluation: Resolution: 170 square miles. Ground Truthed?

Yes. Number of Seasons: 11. Species Included: Black-footed ferret (confirmed and probably sightings) former range (from Hall and Kelson 1979), potential present range, and areas deleted from potential present range (not explained). Distribution From Field Studies. Year of Original Mapping: 1981. Year Updated: 0. Number of Year of Data: 11.

Subjective Evaluation of Mapping System: Gross scale limits the value of these maps, but they have limited value for identifying potentially critical areas.

J.J. Johnson and Associates. 1979. Landmark Plaza and Community Environmental Impact statement. Unpublished, prepared to meet requirements of Summit County Planning Dept., dated July 1979. (ANALYZED DATA)

Location: Summit County Planning Dept., Coalville.

Evaluation: Design: Qualitative discussion of big game, unique rare, and endangered species, and environmental impacts including species list. Timing: unspecified. Analysis Methods: qualitative. -

Value to OIA Study: Conclusions: Habitat loss will occur and human populations will degrade surrounding habitats. Baseline Data: too qualitative. Further Study: none recommended.

Subjective Rating of Document: Too qualitative to be of much value.

J.J. Johnson and Associates. 1981. Environmental Impact Statement for Parley's Summit Resort. Unpublished, prepared to meet requirements of Summit County Planning, dated 23 Apr 1981. (ANALYZED DATA)

Location: Summit County Planning Dept., Coalville.

Evaluation: Design: Qualitative discussion of herptofauna and threatened and endangered species. Timing: unspecified. Analysis Methods: qualitative.

Value to OIA Study: See J.J. Johnson and Associates 1979.

Subjective Rating of Document: See J.J. Johnson and Associates 1979.

J.J. Johnson and Associates. 1982. Frostwood a planned unit development Summit County, Utah, environmental impact statement. Unpublished, prepared to meet requirements of Summit County Planning Dept., dated Apr 1982. (ANALYZED DATA)

Location: Summit County Planning Dept., Coalville.

Evaluation: Design: Qualitative discussion of mammals, birds, amphibians, reptiles, and endangered species occurrence and habitat loss.

Timing: unspecified. Analysis Methods: qualitative.

Value to OIA Study: Conclusions: Habitat loss would occur and human populations would degrade surrounding habitats. Baseline Data: too qualitative. Further Study: none recommended.

Subjective Rating of Document: Too qualitative to be of much value.

John, R.T. 1966. Utah furbearers management recommendations 1965-1966. UDWR Departmental Information Bulletin 66-9, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Beaver harvests and population status increase, no change, and decrease are presented by management unit only.

Nuisance complaints are listed. Muskrat harvests and numbers of trappers are listed for management areas. Timing: 1 year. Analysis Method: Totals and averages for quantitative data.

Value to OIA Study: Conclusions: Makes recommendations for trapping seasons. Baseline Data: Could be used in a limited way for calculation of long term trends. Further Study: none recommended.

Subjective Rating of Document: The quantitative data presented is moderately useful, but the value of the qualitative data is very limited.

John, R.T. 1968. Utah furbearers harvest report 1967-1968. UDWR Publication No. 68-7, Project W-65-R-16 Job C-2, dated Aug 20. 68, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Questionnaires were sent to all licensed trappers and the return (83.8%) was used to determine harvest of beaver, mink, and marten. Includes tables of harvests (beaver & mink) numbers of trappers (beaver & mink) and nuisance permits (beaver) by county.

Also includes 14 year summary of harvest. Timing: 1 season.

Analysis Method: Percentages, averages, and totals were calculated.

Value to OIA Study: Conclusions: Concludes that populations of beaver are stable or increasing and that nuisance complaints declined, and

recommends continued status quo for mink and marten. Baseline Data: Could be used to calculate long term trends. Further Study: none recommended.

Subjective Rating of Document: Provides data on furbearers, but only on a county-wide basis.

John, R.T. 1968. Utah furbearers management recommendations 1967-1968.

UDWR Publication No. 68-8, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Duplicates some of publication 68-7 (John 1968), but also gives harvest and nuisance figures by management unit and population status (decrease, increase, no change, unknown) lists nuisance complaints, and muskrat harvest on state-owned areas in the 1967-1968 season. Timing: 1 year. Analysis Method: unclear.

Value to OIA Study: Conclusions: Makes recommendations for trapping seasons and closed areas. Baseline Data: Could be used in a limited way for calculation of long term trends. Further Study: none recommended.

Subjective Rating of Document: Provides data on furbearers, but only on a county-wide basis.

John, R.T. 1969. Utah furbearers harvest report and management recommendations 1968-1969. UDWR Publication No. 69-11, Project No. W-65-17, Job A-2, dated 1 Aug 69, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Questionnaires were sent to all licensed trappers. The 83.3% response was used to determine harvest and species trapped (beaver, marten, mink). Beaver nuisance complaints, muskrat harvests in refuges, and population status of beaver based on observations of UDWR field personnel (increase, no change, decrease) are also discussed. Beaver harvest is given by management unit only and mink by county. Timing: 1 season. Analysis Method: Extrapolation was used and percents and averages were calculated.

Value to OIA Study: Conclusions: Makes recommendations for trapping seasons and also recommends specific drainage management of beaver as populations are thought to be below carrying capacity in some areas. Baseline Data: Could be used to document long term trends. Further Study: none recommended.

Subjective Rating of Document: Provides a good data base on some furbearers, the main limitation is the large geographic areas discussed.

John, R.T. 1971. Utah furbearers harvest report and management recommendations. UDWR Publication No. 71-81, Project No. W-65-R-19, dated 10 Aug 71, UDWR, Salt Lake City, Utah.

Location: University of Utah, UDWR.

Evaluation: See John (1969).

Keith, J.E. 1971. An economic analysis of the Cisco fisheries of Bear Lake, Utah and Idaho. Thesis. Utah State University, Logan. (ANALYZED DATA)

Location: Utah State University Library, Logan, UT.

Evaluation: Design: Willingness-to-pay data were collected by personal interview each day of the 1970 Cisco run. Opportunity cost of time was calculated and examined as part of total costs of fishing, coefficients of income and opportunity costs of time were compared.

Timing: Jan. 14-20 1970. Analysis Methods: Total use is calculated from sampling percentages. Demand is calculated. Regression analyses, statistical models used.

Value to OIA Study: Conclusions: Opportunity cost of time was found to be a significant factor in consumer's participation and effected the valuation of the recreation considerably. Coefficients of income and opportunity costs were found to be of different sign for rural counties indicating a difference between the two variables. Baseline Data: Contains data that would be valuable for studies of increased fishing pressures on Bear Lake. Further Study: Further refinement of the opportunity cost of time is needed. The concept of time costs has not been empirically evaluated for a recreation good.

Subjective Rating of Document: Some management value for Cisco fishery on Bear Lake, policy implications of increased fishing pressures.

Kimbal, J. 1972. North slope planning area - wildlife inventory and plan. Unpublished report, dated Feb. 1972, Wasatch-Cache National Forest, Salt Lake City, Utah. (ANALYZED DATA)

Location: U.S. Forest Service Evanston and Mountain View Ranger Districts.

Evaluation: Design: Qualitative discussions of waterfowl, furbearers, big game, data on rare and endangered species, upland game birds, and songbird frequency occurrence in different alpine and coniferous habitat types. Unknown: unknown. Analysis Methods: percent frequency was calculated for songbird habitat associations.

Comments: A copy of this document was not located in Utah, this evaluation is from written descriptions filed in the Supervisor's Office. Eight or more maps are part of this document.

King, S. and A. Muir. 1971. Big game range inventory 1969-1970. UDWR Publication No. 71-3. Project W-69-R-18, dated June 1971, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: See Coles and Pederson (1967)

Value to OIA Study: Baseline Data: Provides valuable baseline data for deer herd unit 2 (acre) and for deer herd unit 5 (Woodruff). See Figure D-1.

Type of Map: Habitat

Area Covered: Deer herd units 2 (Cache) and 5 (Woodruff)

Scale: varies, no scales given on maps.

Evaluation: Habitat Types Mapped: Sagebrush, sparse sagebrush, browse, juniper, sagebrush-grass, agricultural land, reseeding (preceding mapped on winter range only), winter range (upper, lower, and severe winter limits) and migration routes. Resolution: habitat types: about 40 acres, seasonal ranges: about 30 acres, migration: 1/3 mile. Ground Truthed? Yes. Number of Seasons: 1.

Subjective Evaluation of Mapping System: Lack of scale and small size of maps limits value somewhat, but the maps are useful to reference the text.

King, S. and B. Olson. 1972. Big game range inventory 1970-1971. UDWR Publication. No 72-10, Project W-65-R-20, dated Sept. 72, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: See Coles and Pederson (1967)

Value to OIA Study: Conclusions: Contains data on Unit 6 (Lost Creek), and Unit 24 (Blacks Fork) in the study area. Also has data on 4 other units outside the study area (Ogden, Davis County, Salt Lake, and North Book Cliffs) See Figure D-1. Baseline Data: Provides baseline data for 3 deer herds in the area.

Subjective Rating of Document: Valuable data on 3 deer herds are in this report.

Leatham, J.P., and S.D. Bunnell. 1979. Utah upland game annual report 1978. UDWR Publication 79-12, Project W-65-R-D-27, Job A-4, Salt Lake City, Utah. ANALYZED DATA

Location: University of Utah, UDWR.

Evaluation: See UDWR (1965).

Leatham, J.P., and J.A. Roberson. 1981. Utah upland game annual report 1980. UDWR Publication 81-5, Project W-65-R-29, Job A-4, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: see UDWR (1965).

Loo S.K.Y. 1960. Distribution and movements of some fishes in Bear Lake, Utah-Idaho, 1958-59. Thesis. Utah State University, Logan, Utah. (ANALYZED DATA)

Location: Utah State University Library, Logan, UT.

Evaluation: Design: Fishes were sampled by bottom-set gill nets set at 4 depth classes. Mark and release was attempted but was unsuccessful. Timing: 2 years. Analysis Methods: Percentages and numbers were calculated for each depth.

Value to OIA Study: Conclusions: Greatest species diversity was encountered at shallow depth. Distribution of some species suggested that water temperature rather than depth controlled their distribution. Baseline Data: Contains data that would be valuable for studies of Bear Lake. Further Study: This paper should be used for background if studies of Bear Lake are undertaken. Subjective

Rating of Document: Has value for background if studies of Bear Lake are undertaken. Does not directly address impacts such as sediment, fishing pressure, etc.

McCormack, R.J. 1951. A population study of the South Cache elk herd. Thesis. Utah State Agricultural College, Logan, Utah. (ANALYZED DATA)

Location: Utah State University Library, Logan, Utah.

Evaluation: Design: Strip census, aerial census, and hunter bag checks were used. Timing: 2 years. Analysis Methods: Percentages averages and ratios were calculated.

Value to OIA Study: Conclusions: Aerial counts required 5 hours of flight time. Preseason hunts were necessary to reduce damage. October hunts reduced the population without changing migration routes or wintering range, and November hunts could be used to manipulate migration routes and wintering range. Baseline Data: May have some value for hunter success rates, bull:cow and cow:calf ratios and population adjacent to the study area. Further Study: Use of November hunts to manipulate migration routes and winter range may be worthy of further study.

Subjective Rating of Document: Provides historical context for elk peripheral to the study area, and suggests a potentially useful management technique (late season hunts).

May, B.E., J.D. Leppink, and R.S. Wydoski. 1978. Distribution systematics, and biology of the Bonneville cutthroat trout, Salmo clarki utah. UDWR Publication 78-15, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Samples from suspected pure strain populations were analyzed by electrophoresis. Also contains a qualitative discussion of management. Timing: At least 5 years. Analysis Methods: Totals, averages, numbers per mile (km) and per acre (ha) were calculated.

Value to OIA Study: Conclusions: Bonneville cutthroat could be managed as sport fish and many be especially desirable because of piscivorous habits. Baseline Data: no value. Further Study: none recommended.

Subjective Rating of Document: Presents some useful observations on Bonneville cutthroat and incorporates a good review of literature.

Millard Consultants. 1979. Red Pine Lodge Park West Utah, an environmental impact statement. Unpublished, prepared to meet requirements of Summit County Planning Dept., dated Oct. 79.

Location: Summit County Planning Dept., Coalville.

Evaluation: Design: Qualitative and extremely brief discussion of habitats. Timing: unspecified. Analysis Methods: qualitative.

Value to OIA Study: Conclusions: People, recreational vehicles, and pets have already forced wildlife from the site. Baseline Data: no value. Further Study: none recommended.

Subjective Rating of Document: Too qualitative and brief to be of any value.

Mountain West Design. n.d. Eagle Springs planned community natural resource analysis. Unpublished, prepared to meet the requirements of Bear Lake Regional Commission. (ANALYZED DATA)

Evaluation: Design: Qualitative discussion of deer winter range and sage grouse strutting areas on or near property, mostly from interviews with LaVon Thomas of UDWR. Timing: 1 season field reconnaissance. Analysis Methods: none, qualitative.

Value to OIA Study: Conclusions: Conclude that lower elevation development would have no impact on wildlife, high elevation would affect winter range, but could be used spring, summer and fall. Baseline Data: too qualitative. Further Study: none recommended.

Subjective Rating of Documents: Too qualitative to be of value.

Nish, D.H. 1967. Utah upland game bird harvest 1966. UDWR Publication 66-7, Project W-65-R-15, dated 1 June 67, Salt Lake City, Utah.

Location: University of Utah, UDWR.

Evaluation: See UDWR (1965)

Comment: Includes percent of eligible hunters hunting each species and long term data from previous reports are in the appendices.

Nish, D.H. 1968. Utah upland game bird harvest 1967. UDWR Publication 68-6, Project W-65-R-16, dated 1 June 68, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: See UDWR (1965)

Comment: Long term average data varies from 4-19 years. Rich and Summit Counties were reopened to sage grouse hunting for first time since 1963 with reduced bag limits. Rich County produced the second highest and Summit County produced the fourth highest harvest in Utah with 2nd and 6th highest pressures.

Nish, D.H. 1969. Utah upland game bird harvest 1968. UDWR Publication 69-8, Project W-65-R-17, dated 1 July 69, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: See UDWR (1965)

Comment: Includes cottontail data: percent of harvest and pressure by month of season, and comparison with 1967 data, sage grouse: Rich and Summit still had reduced bag and were second and fifth in harvest and 3rd and 5th in pressure.

Nish, D.H. 1971. Utah upland game bird harvest 1970. UDWR Publication No. 71-7, Project W-65-R-19, dated 1 July 71, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Separate questionnaires were sent to 14,730 (45.1% return) game bird hunters, 14,693 cottontail hunters, and all turkey hunters. Remainder: see UDWR (1965).

Comment: sage grouse: no data on hunt status, but only Summit County has in top 5 (tied for 5th) counties in pressure.

Nish, D.H. 1972. Utah upland game 1972. UDWR Publication 72-11, Project W-65-R-D-20, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: See UDWR (1965)

Nish, D.H. 1973. Utah upland game 1972. UDWR Publication 73-49, Project W-65-R-D-21 Job A-4, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: See UDWR (1965)

Nish, D.H. 1974. Utah upland game 1973. UDWR Publication 74-9, Project W-65-R-D-22 Job A-4, Salt Lake City, Utah (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: See UDWR (1965)

Nish, D.H. 1977. Utah upland game 1976. UDWR Publication 77-6, Project W-65-R-D-24 Job A-4, Salt Lake City, Utah (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: See UDWR (1965)

Nunan, R.L. 1972. Effect of Bear River storage on water quality in Bear Lake, Utah-Idaho. Thesis. Utah State University, Logan, Utah. (ANALYZED DATA)

Location: Fisheries and Wildlife Department, Utah State University, Logan, UT.

Evaluation: Design: Analyzed nature and causes of changes in Bear Lake salinity values caused by use of lake as storage reservoir by testing hypothesis that lake water is being diluted by diversion of Bear River waters into lake since 1912. Water chemistry samples from 6 stations were analyzed. A water-salt budget model was used to analyze historical records. Chemical analyses were made according to standard methods. Timing: 1971. Analysis Methods: Analyses of variance, Newman-Keuls multiple mean comparison, data tabulated (means, range).

Value to OIA Study: Conclusions: Water chemistry data were obtained (calcium, magnesium, sulphate, potassium, chloride, carbonate, pH, temperature, conductivity), concentration of each mineral has decreased 30-50% since 1912, a water-salt model was constructed, based on annual inflow, outflow, and evaporation, which predicted mineral concentrations. Data uphold theory that salinity of the lake is being diluted. Prior to 1912, salinity was increasing due to greater evaporation than inflow. Baseline Data: Suitable for baseline data. Further Study: Water-salt budget model should be refined to include newer salinity, hydrology models.

Subjective Rating of Document: Valuable data on water chemistry of Bear Lake. Data might be used if further studies of Bear Lake are undertaken.

Nyquist, D. 1967. Eutrophication trends of Bear Lake. Idaho-Utah and their effect on the distribution and biological productivity of zooplankton.

Dissertation. Utah State University, Logan, Utah. (ANALYZED DATA)

Location: Utah State University Library, Logan, Utah.

Evaluation: Design: 23 species of zooplankton and 9 other species of flora and fauna were collected and 17 physical and chemical

parameters were measured during sampling in Bear Lake to 1) establish a record of current zooplankton population; 2) compile a qualitative and quantitative standard for future comparison; 3) assess source and quantity of present nutrient load; 4) investigative effect of present nutrient additions on zooplankton productivity. Timing: 17 months (1964-1965). Analysis Methods: Correlation and regression analysis on relationships between chemical analysis and associated zooplankton and on 3 lake zones investigated water quality analysis. Value to OIA Study: Conclusions: Defined various environmental requirements necessary for maintenance of individual species. Bacteriological testing of Bear Lake waters revealed large percentage of littoral and limnetic zones presented problems with respect to public use and water quality. Baseline Data: Valuable data for studies of Bear Lake, lists of zooplankton species present and measurements of chemical parameters of lake waters. Further Study: This paper should be used for background if studies of Bear Lake are undertaken.

Subjective Rating of Document: Valuable information on management of Bear Lake. Addresses some of the impacts on water quality of increased human development.

Olsen, D.W. 1977. A literature review of pheasant habitat requirements and improvement methods. UDWR Publication No. 77-7, Project W-65-R-D-25, Job B-8, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Literature review considering food habits, seasonal habitats and cover, agricultural lands, and habitat improvements. Timing: NA Analysis Methods: NA

Subjective Rating of Document: Useful as a review of literature.

Olson, B.C. 1976. Big game range inventory 1975. UDWR Publication 76-10, Project W-65-R-D-24, Job A-6, dated April 1976, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: See Coles and Pederson (1967).

Value to OIA Study: Conclusions: All units are outside the study area.

Olson, B.C. 1977. Big game range inventory 1976. UDWR Publication 77-3, Project W-65-R-D-24, Job A-6, dated August 1977, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: See Coles and Pederson (1967).

Value to OIA Study: Conclusions: All units are outside the study area.

Olson, B.C. 1977. Big game range inventory 1976. UDWR Publication 77-3, Project W-65-R-D-24, Job A-6, dated August 1977, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: See Coles and Pederson (1967).

Value to OIA Study: Conclusions: All units are outside the study area.

Olson, B.C., and J.R. Logan. 1974. Big game range inventory 1972-1973. UDWR Publication 74-16, Project W-65-R-D-22, December 1974, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: See Coles and Pederson (1967).

Value to OIA Study: Baseline Data: All herd units are outside the study area.

Pacific Southwest Inter-agency Committee, Water Resources Council. 1971. Fish and wildlife Appendix XIII, Great Basin Region comprehensive framework study. Unpublished report, dated June 1971. (ANALYZED DATA)

Location: U.S. Soil Conservation Service, Salt Lake City.

Evaluation: Design: Includes discussions of existing (1965) supply and demand for fish and wildlife, future supply and demand, projected unmet demands, and means to meet demands compiled by a number of agencies. Timing: Unknown. Analysis Methods: Compilation of existing and projected program targets.

Value to OIA Study: Conclusions: Projects shortages of big game in Wyoming and Idaho parts of the Bear River. Makes general recommendations for wildlife management, particularly regarding water projects. Baseline Data: Little or no value due to the scale of the project. Further Study: None recommended.

Subjective Rating of Document: Provides a useful regional context but is outdated.

Petersen, S.R. 1969. Ecology of waterfowl in the Uinta Mountains. Publication No. 69-1, Project W-29-22, dated 7 March 1969 (Also: Petersen, S.R. 1969. Waterfowl ecology and utilization of Uinta mountain water areas. Thesis. Utah State University, Logan, Utah). (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Waterfowl use was observed on about 24 square miles (six study areas) in the Uintas by air and foot. Dates of freezing, elevation, topographic, water quality, aquatic invertebrate samples, and vegetative data were collected.

Timing: 2 years. Analysis Methods: Percentages and

averages were calculated and total production in the Uintas was extrapolated.

Value to OIA Study: Conclusions: Found 16 species using the Uintas, 6 were breeders, making up 5 percent or less of the total waterfowl production in Utah. The 8,000 - 9,500 foot levels had the highest use. Baseline Data: Could be used for site specific areas although waters are not well identified. Further Study: May be worthwhile to study waterfowl in artificial impoundments in the lower elevations if necessary for mitigation.

Subjective Rating of Document: Provides valuable data on waterfowl in the Uintas, and could be useful for planning. Limited value for impact assessment.

Platts, W.S., and R.L. Nelson. 1982. Livestock-fishery interaction studies, Big Creek, Utah. Unpublished report prepared for BLM Salt Lake City, Utah, by Intermountain Forest and Range Experiment Station Forestry Science Lab, Boise, Idaho. (ANALYZED DATA)

Location: Copy not available.

Subjective Rating of Document: A copy was not obtained but this continues the work in draft (1978).

Comment: See also a paper presented by Platts at the Wildlife-Livestock Relationships Symposium, 1981.

Popov, B.H. 1949. The introduced fishes, game birds, and game and fur-bearing mammals of Utah. Thesis. Utah State University, Logan, Utah. (ANALYZED DATA)

Location: Utah State University Library (special collections), Logan, Utah.

Evaluation: Design: Histories of introductions (some re-introductions) and brief descriptions of 25 fish, 6 game birds, and 5 game and fur-bearing mammals throughout Utah are given with maps and tables of introduction into Utah. Timing: Based on data from 1870-1949. Analysis Methods: qualitative.

Value to OIA Study: Conclusions: Many introductions were not successful. Many of the fish species were introduced into Bear Lake. Baseline Data: Limited value. Further Study: None recommended.

Subjective Rating of Document: Possible value as history of introduced species in Utah.

Provan, T.H. 1978. Utah furbearer harvest report and management recommendations 1977-78. UDWR Publication 78-10, Project W-65-R-26, Job A-3, dated August 1978, UDWR, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: See John (1969).

Radant, R.D. 1976. Fisheries inventory of the Provo River system and Main Creek. Unpublished report, prepared by UDWR for U.S. Bureau of Reclamation, dated 15 November 1976, Salt Lake City, Utah. (ANALYZED DATA)

Location: U.S. Bureau of Reclamation, Provo, Utah.

Evaluation: Design: Stream habitats were measured at 5 transects on each of 10 sections, water quality, zoo plankton, and macroinvertebrate populations were sampled, and fish were sampled by electroshocking. Includes Provo River and 15 mountain lakes. Timing: 14 months. Analysis Methods: percentages and averages were calculated, confidence intervals (standard error) calculated for fish populations.

Value to OIA Study: Conclusions: Conclusions discuss and summarize data. Baseline Data: Good quality baseline data. Further Study: None recommended.

Subjective Rating of Document: This is a good quality inventory of the fisheries resources in the area covered.

Rawley, E.V. 1954. Utah furbearers: management recommendations and harvest report. (Also titled: Utah furbearers 1954-1955). Unpublished report, Project 65-R-3, Utah Department of Fish and Game, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah Library (Western Americana Collection), UDWR offices.

Evaluation: Design: Beaver: population data collected by foot and horse surveys, indicates previously unknown populations found by aerial surveys, gives 1954-1955 harvests and harvest recommendations by drainage and management areas. Lists transplant sites, numbers transplanted, and damage reports. Marten: habitat data from transects (tree species and numbers of snags, no control area), located at marten sign in snow in the Uintas and food habits by analysis of four scat. Harvest report: number of beaver and mink trapped by county and number of muskrat trapped on refuges. Also has an evaluation of methods for aging beaver. Analysis Methods: Totals and averages. Beaver population, data is subjective and qualitative - three categories (understocked, properly stocked, and overstocked).

Value to OIA Study: Conclusions: Beaver: conclusions presented as harvest recommendations, marten: presents conclusions on forest density and food habits of marten of questionable value due to small sample and lack of control. Baseline Data: Limited to simple presence and absence of beaver. Harvest data could be used to document long term trends. Further Study: None recommended. See later UDWR furbearer reports.

Subjective Rating of Document: Relatively little value to OIA due to the age and subjective nature of most data.

Area Covered by Map: All of Utah.

Scale: unknown 8-1/2 x 11" state map.

Evaluation (Species Occurrence Maps): Species Included: Marten - 7 areas of known occurrence mapped, population estimates included for 2 of 7 areas. Distribution from Field Studies: trapper's reports. Year of Original Mapping: 1954. Year Updated: None. Number of Years of Data: unknown.

Subjective Evaluation of Mapping System: May have some small value for documentation of continued occurrence or absence.

Other Comments: Method of estimating populations not specified.

Rawley, E.V. 1955. Utah furbearers: management recommendations and harvest report. (Also titled: Utah furbearers 1954-55.) Unpublished report, Project 65-R-3, Utah State Dept. of Fish and Game, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah Library (Western Americana Collection), UDWR.

Evaluation: Design: Beaver: population data by foot and horse surveys; indicates previously unknown populations found by aerial surveys, gives 1954-1955 harvests and harvest recommendations by drainage and management area. Lists transplant sites and numbers transplanted. Also lists damage reports. Marten: habitat data from belt transects. Data consists of tree species and number of snags in transects, no control. Transects centered on marten sign in snow in Uintas. Food habits evaluated by analysis of 4 scats. Furbearer Harvest Report: numbers of furbearers (beaver, muskrat, and mink) trapped (raw data). Study of aging methods for beaver - not evaluated. Timing: One season, but follows up previous work and provides ongoing data. Analysis Methods: Beaver population data is subjective, placed in 3 population categories (understocked, properly stocked, overstocked). Marten data simply presented and averaged.

Value to OIA Study: Conclusions: Beaver conclusions incorporated into harvest recommendations, marten conclusions of questionable value due to sample size and lack of control. Baseline Data: Limited to simple occurrence/absence for beaver in various drainages, none for marten. Furbearer harvest could be used to document long-term trends in populations. Further Study: None recommended. UDWR follow-ups evaluated for other citations.

Subjective Rating of Document: Little or no value to OIA due to subjectivity, poor design, and age of data.

Rawley, E.V. 1972. Statistical data concerning Utah hunting and fishing license buyers. UDWR Publication No. 72-4, Project FW-9-R-1, dated May 1972, Salt Lake City, Utah.

Location: University of Utah, UDWR.

Evaluation: Design: Data on 1969 license buyers was correlated with 1970 census data and activities of combination license buyers, small game license buyers, fishing license buyers, a compilation of the preceding, and activities of deer and combination license buyers are correlated with estimated 1970 county populations. Timing: 1 year. Analysis Methods: percentages, averages, and extrapolations were used.

Value to OIA Study: Conclusions: Various conclusions are made about hunter characteristics. Baseline Data: May be used on a county-wide basis. Further Study: Could be used for hunting management where human population growth occurs.

Subjective Rating of Document: Could be useful on a county-wide basis.

Rawley, E.V. 1979. Synoptic plan for Utah's wildlife resources. UDWR Publication No. 79-14. Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Qualitative statewide discussion of history of Utah wildlife management current administration and goals. Timing: N/A. Analysis Methods: qualitative.

Subjective Rating of Document: Gives a broad overview and historical perspective.

Rawley, E.V. 1980. Species plan for Utah's big game resources. UDWR Publication No. 80-14, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Provides life histories, statewide distribution maps, demand projections, description of needs and problems, programs to solve foregoing and goals and objectives for deer, elk, antelope, moose, bighorn sheep, buffalo, and mountain goat. Timing: 1980-1990. Analysis Methods: not specified.

Value to OIA Study: Conclusions: No conclusions, planning document.

Baseline Data: no value. Further Study: none recommended.

Subjective Rating of Document: Gives perspective for UDWR programs.

Other Comments: USFWS has digitized the originals of these maps.

Rawley, E.V. and W.J. Bailey. 1972. Utah upland game birds. UDWR publication No. 63-12, revised 1972, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Qualitative description of habitat, nesting, food, and status. Includes small state-wide distribution maps.

Timing: unknown. Analysis Methods: unknown.

Value of OIA Study: Conclusions: None. Baseline Data:

Distribution maps could be used to show range expansions or extirpation. Further Study: none recommended.

Subjective Rating of Document: The major value of this publication is to allow quick determination of ranges or habitats of upland game birds.

Comment: Originals of maps have been digitized by USFWS.

Reeves, H.M. 1954. Muskrat and waterfowl production and harvest on Dingle Swamp, Bear Lake County, Idaho. Thesis. Utah State Agricultural College, Logon, Utah. (ANALYZED DATA)

Location: Utah State University Library, Logan, Utah.

Evaluation: Design: Observation of muskrats and waterfowl were made from the air and on foot. Trapping, litter examination and trapping and hunting records were also used. Timing: 2 years. Analysis Methods: Averages and percentages of production and characteristics were calculated.

Value to OIA Study: Conclusions: Data on muskrat habitats, populations, harvests, litter numbers and sizes, sex ratios, and survey costs are presented. Data on waterfowl species, numbers, peak use, nesting habitats, waterfowl-grazing interactions, phenology, clutch sizes, causes of failure, and harvest are given. Data is generally numerical and descriptive, with few recommendations for management. Baseline Data: Valuable baseline data for post-irrigation/hydropower era. Further Study: Could serve as baseline for future studies.

Subjective Rating of Document: The main value of this document is for baseline data.

Regenthal, A.F. et. al. 1960. Federal aid in fish restoration investigations of specific problems of Utah's fishery. UDWR Departmental Information Bulletin 60-2, Dingell-Johnson Project No. F-4-R-4, Jobs L and M. (ANALYZED DATA)

Location: University of Utah and UDWR.

Evaluation: Design: Creel censuses and angler interviews were conducted at Fish Lake, Scotfield Reservoir, Deer Creek Reservoir, and Strawberry Reservoir. Fin-clipped fish were released into Fish Lake, Scofield Reservoir, and Strawberry Reservoir. Timing: 1

year. Analysis Methods: Data presented result from extrapolation and calculation of percentages and averages. Some data are compared with 1955 and 1956 data.

Value to OIA Study: Conclusions: Data is presented on fishing pressure, rate of success, and total harvest for each lake.

Baseline Data: Little or no value - outside study area. Further Study: None recommended.

Subjective Rating of Document: Presents good historical fisheries data, but is outside study area.

Richens, V.B. 1967. An evaluation of control on the pocket gopher, Thomomys Talpoides, on the Cache National Forest, Utah. Dissertation. Utah State University, Logan, Utah. (ANALYZED DATA)

Location: Utah State University Library, Logan, Utah.

Evaluation: Design: A comparative study (by snap-trapping and mound and cast counts) was made between 2 gopher-infested ranges (Rich and Cache counties) - one controlled by poison grain treatment and the other uncontrolled to determine the effect of successive annual control on gopher population, vegetation density, plant species composition and forage yield, and to evaluate costs and effectiveness on control. Analysis Methods: Regression analysis, line-plot transects, trap blocks.

Value to OIA Study: Conclusions: Gopher population figures for treatments show marked reduction after one year of control, but little or no reduction in succeeding years, retreatment merely held population down to constant level from which recovery resulted in 1 year. Trapping and mound counts showed good correlation with gopher population. Costs for control (for 4 year period 1957-1961) averaged \$1.13/acre for initial treatments and \$0.51/acre are re-treatment.

Baseline Data: Baseline data on gopher populations in Rich County.

Subjective Rating of Document: Valuable information on gopher control, may be important on areas to be revegetated.

Sabine, N. n.d. Habitat utilization by bald eagles wintering in west-control Utah. Unpublished report, prepared for BLM, USFWS, UDWR, and Brigham Young University. (ANALYZED DATA)

Location: BLM, Salt Lake District, Salt Lake City, Utah.

Evaluation: Design: 7 bald eagles were trapped and radio-tagged in the Rush Valley (near Vernon) and tracked. Timing: 1 season.

Analysis Methods: qualitative.

Value to OIA Study: Conclusions: General recommendations for management are made. Although not discussed, at least one of these birds was relocated at Woodruff Narrows. Baseline Data: No

value. Further Study: Continued study may be valuable to determine the role of Woodruff Narrows relative to Rush Valley.
 Subjective Rating of Document: This document has little value to the OIA project.

Schonholtz, R.G. 1978. Bear Lake wetlands maps. Unpublished maps, prepared by Sacramento District US Army Corps of Engineers, Sacramento, CA. (MAPPING)
 Location: Copies at USACE Salt Lake City Field Office and Bear Lake Commission, originals at USACE Sacramento District Office, Sacramento, CA

Contact Person: Fish Haven: Craig Thomas; Salt Lake City: Tom Skordall; Sacramento: Tom Coe, Jim Gibson

Type of Map: Habitat

Area Covered: Bear Lake, Utah and Idaho, exclusive of Bear Lake National Wildlife Refuge

Scale: 1:24,000

Evaluation (Habitat Maps): Habitat Types Mapped: Wetlands (areas under 404 jurisdiction and areas requiring field determination of jurisdiction). Resolution: (Description or Dimension of Smallest Polygon): 1.5 acres. Ground Truthed? Yes. Number of Seasons: 1

Evaluation (Species Occurrence Maps): Year of Original Mapping: 1978
 Years Updated: 0 Number of Years of Data: 1

Subjective Evaluation of Mapping System: These maps are useful for determining if an area is under or may be under 404 jurisdiction. Wetland types are not differentiated and some wetlands were not mapped.

Schwinn, M.A., and A.W. Heggen. n.d. A survey of endangered and unique wildlife of the Price River Resource Area and a portion of the San Rafael Resource Area. Unpublished report, prepared for BLM State Office by UDWR, Salt Lake City, Utah. (ANALYZED DATA)

Location: BLM State Office, Salt Lake City, Utah.

Evaluation: Design: Literature reviews and field searches were conducted for peregrine falcons, bald eagles, osprey, spotted owl, black-footed ferret, Utah prairie dog, spotted bat, and humpback chub.
 Timing: 1 season. Analysis Methods: A T-test was used to compare prairie dog skulls collected with museum specimens.

Value to OIA Study: Conclusions: Conclusions reflect presence or absence of the species, and have little or no value to OIA.
 Baseline Data: No value - outside study area. Further Study: None recommended.

Subjective Rating of Document: Little value to OIA study except to illustrate the type of work that could be contracted to UDWR.

Schwinn, M.A., and C. Minden (eds.) 1979. Utah reptile and amphibian Lati-long distribution. Unpublished report prepared by non-game section, UDWR, Salt Lake City, Utah (ANALYZED DATA).

Location: University of Utah and UDWR.

Evaluation: Design: Includes a matrix of status, habitat, and abundance (many sub-categories) and asks for sightings in 1 degree blocks. Timing: NA Analysis Methods: Literature review

Value to OIA Study: Conclusions: The matrix forms the conclusion.

Baseline Data: No value Further Study: none recommended

Subjective Rating of Document: The matrix of habitats could be used where reptiles and amphibians were a concern.

Shaw, M. n.d. Listing of contents of 2600 wildlife files at Wasatch-Cache National Forest Supervisor's Office. Unpublished manuscript, Wasatch-Cache National Forest, Salt Lake City, Utah. (RAW DATA)

Location: Wasatch-Cache National Forest, Supervisor's Office, Salt Lake City, Utah.

Evaluation: Design: Listing of contents of files, letters and memos.

Timing: NA Anticipated Completion Date: completed

Value to OIA Study: Geographic Area Covered: Wasatch-Cache National Forest. Baseline Data: NA Further Study: Some items may be useful for other studies.

Subjective Rating of Document: Main value is as a guide to the files.

Comments: Highlights: raptor electrocution report (negative), Sikes Act program, letters regarding fish ladders. Notes from Winn's work, UDWR big game data, gopher control notes, habitat improvement project notes and survey notes from outside the study area.

Shaw, W.W. 1971. The effects of available water upon populations of chukar partridge on desert mountains of Utah. UDWR publication No. 71-5, Salt Lake City, Utah (also: Thesis, Utah State University, Logan, Utah). (ANALYZED DATA)

Location: University of Utah

Evaluation: Design: Water sources (guzzlers only) were turned off on one mountain range populated by chukars and distribution, food habits, productivity, survival, and vulnerability to hunters compared with a control group by censusing hikes and observation of marked birds.

Timing: 2 years Analysis Methods: Percentages, averages and

confidence intervals at 95% limits were calculated.

Value to OIA Study: Conclusions: Found no significant differences between the groups except in distance traveled from water (water deprived moved less). Baseline Data: Little or no value- outside study area. Further Study: None recommended.

Subjective Rating of Document: Probably of little value to OIA since study area has much more free water than the area studied in this project.

Smith, A.D., et. al. 1972. The effects of deer and domestic livestock on aspen regeneration in Utah. UDWR Publication 92-1, Project W-105-12, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah and UDWR.

Evaluation: Design: Inventories of aspen sprouts and forage were done on 4 study areas in the state on 9.6 square foot or 0.001 acre plots, plots were subjected to a variety of treatments and the effects of grazing and/or browsing were measured by marked stems, pellet and cowchip counts, forage production estimates, and observations of causes of injury. Timing: 8 years Analysis Methods: Percent ages and averages were calculated.

Value to OIA Study: Conclusions: Found that aspen can regenerate under heavy grazing pressure, but that continued sheep grazing can eliminate it. Deer had little effect. Complete removal of overstory produced the best regeneration and the first year was most critical. Baseline Data: Little or no value. Further Study: May be worth following up for reclamation or mitigation.

Subjective Rating of Document: Provides good data on aspen regeneration-livestock interactions.

Smith, A.D. and D.D. Doell. 1968. Guides to allocating forage between cattle and big game on big game winter range. UDWR Publication 68-11, Project W-105-R; Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: Design: Herbaceous species were closely clipped around bitterbrush and resulting shoot growth was measured. Grazing by cattle at 40 and 60% utilization was studied in respect to herbage and browse canopy cover, phenology, and utilization (estimated ocularly). Both summer and fall grazing were studied. Timing: 4 years total (2 years herbaceous clipping, 2 other years grazing) Analysis Methods: Percent utilization and cover averages, analysis of variance, and regressions were calculated or used.

Value to OIA Study: Conclusions: Herbage clipping increased bitterbrush shoot growth by 48-51%. Early season grazing resulted

in equal use of forbs and grasses and little use of bitterbrush except under heavy stocking. Mid-season grazing resulted in a decline in grass and forb use and increase in bitterbrush use. Late-season grazing resulted in the highest use of bitterbrush. Study was not long enough to document vegetation changes. Baseline Data: Little or no value Further Study: May be useful to follow up on range types found in overthrust area.

Subjective Rating of Document: Provides potentially useful insights into cattle-big game interactions on winter range.

Sparks, E.A. 1962. Big game harvest report 1961. UDWR Departmental Information Bulletin 62-1, Project W-65-R-10, dated 15 Mar 62, Salt Lake City, Utah (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: See Stapley (1970)

Sparks, E.A. 1963. Big game harvest report 1962. UDWR Departmental Information Bulletin 63-1, Project W-65-R-11, dated 15 Mar 63, Salt Lake city, Utah (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: See Stapley (1970)

Sparks, E.A. 1963. Utah furbearers 1962-1963. Unpublished report, Project W-65-R-11, Job C-2, dated 31 Aug. 1963, UDWR, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Beaver data is presented by county and management unit. See John (1966).

Sparks, E.A. 1981. Species list of vertebrate wildlife that inhabit Utah. UDWR Publication No. 81-2, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: Design: Species list broken down by region and brood habitat classes from literature and interviews. Timing: NA
Analysis Methods: qualitative.

Value to OIA Study: Conclusions: none Baseline Data: no value

Further Study: none recommended

Subjective Rating of Document: Of little value, more detailed information can be found elsewhere, but this document does compile mammals, birds, fish, and herps in one publication.

Sparks, E.A., and A.W. Kinskey. 1960. Utah furbearers: management recommendations and harvest report. (Also titled: Utah furbearers 1959-1960) Utah Dept. of Fish and Game, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah (Library - Western Americana Collection)

Evaluation: See Draney (1957).

Value to OIA Study: Conclusions: All beaver populations within the study area: "no change."

Speth, R.L. 1966. Molt patterns in the Great Basin pocket mouse, Perognathus parvus. Thesis. Utah State University, Logan, Utah. (ANALYZED DATA)

Location: Biology Department, Utah State University, Logan, Utah.

Evaluation: Design: 50 adult and 6 juvenile Perognathus parvus olivaceus Merriam were collected and retained in captivity in order to establish the molt pattern, determine the number and sequence of molts during the annual cycle, and provide a partial basis for the segregation of juveniles and adults. 491 museum species were also examined. Timing: July 1964 - April 1966. Analysis Methods: Data tabulated.

Value to OIA Study: Conclusions: P. Parvus molts 2 times each year, in late winter and in summer. Hair replacement follows the same definite topographic patterns in both molts. The molt pattern of juveniles is the same as that of adults, but juveniles can be segregated from adults by pelage differences, repeated examination of molts in live animals was found to be a more reliable indication of the number of molts per year than the study of museum specimens.

Baseline Data: No value. Study specimens taken from Rich County (in OIA study area) and Box Elder County (outside study area).

Further Study: None recommended.

Subjective Rating of Document: Little or no value to OIA study.

Stapley, H.D. 1970. Utah big game harvest 1969. UDWR Publication No. 70-4, Project W-65-R-18 dated 15 Mar 70, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: Design: 34,777 questionnaires were sent to licensed hunters and the 67% return was used to calculate deer harvest and success rate (control, archery, and general), elk harvest and success rate, antelope harvest and success rate moose harvest, buffalo harvest, and desert bighorn harvest. Total hunters are tabulated for a 24 year period, and qualitative and quantitative histories of management and hunting are given for each species and type of hunt. Data by management unit is included in the text for all but deer, which are in the appendix. Timing: 1 season Analysis Methods: Percents and averages are calculated for all and confidence intervals (derived from standard error) are calculated for deer.

Value to OIA Study: Conclusions: Makes management recommendations for 1970 seasons Baseline Data: Could be used to calculate long term trends Further Study: None recommended

Subjective Rating of Document: Provides exhaustive data on big game harvest by management units.

Summers, S.A. 1979. Blood chemistry changes in three salmonid species subjected to hooking stress. Thesis. Utah State University, Logan, Utah. (ANALYZED DATA)

Location: Fisheries and Wildlife Department, Utah State University, Logan Utah.

Evaluation: Design: 3 species of salmonid game fishes (cutthroat trout, brook trout, and arctic grayling) were stressed by hooking and playing for standardized periods of time, blood chemistry parameters were monitored up to 72 hrs. after capture to determine delayed mortality and to provide suggestions to minimize losses of released fish. Timing: June-October 1974. Analysis Methods: Blood chemistry analyses (lactate, hemoglobin, glucose, chloride). Data taken on fork length, sex & physical abnormalities. Data analyzed using non-parametric weighted mean T-tests.

Value to OIA Study: Conclusions: Species exhibited variability in their recovery response indicating that some species may be better suited to catch-and-release fishing (e.g. cutthroat trout) than are other species (e.g. brook trout). In general, however, size of fish, condition of fish, temperature of the water body, and the terminal gear appear to be as important in formulating catch-and-release management programs as does the fish species to be managed.

Baseline Data: Contains data on arctic grayling and brook trout obtained from Sand Lake and Ibantic Reservoir in the upper Weber River drainage, Summit Co., Utah (on study area). Further Study: More study recommended on wild trout populations. Larger sample sizes needed and further study is required to monitor delayed mortalities beyond 72 hrs. An attempt should be made to correlate species maturity or spawning readiness to response and recovery levels.

Subjective Rating of Document: Valuable for fisheries management.

Summit County Planning Department. 1978 Summit County Master Plan. Unpublished, dated Oct. 78, prepared by Summit County Planning Dept., Coalville, Utah. (ANALYZED DATA)

Location: Summit County Planning Dept., County Courthouse, Coalville, UT

Contact Person: Stan Strebel

Value to OIA Study: Geographical Area Covered: Summit County, UT

Baseline Data: Not repeatable Further Study: None

recommended Potential For Use in Wildlife Management: Mentions need to refer to wildlife data in planning decisions and requires an EIS for developments (which are reviewed by UDWR).
Subjective Rating of Document: Very little value to OIA.

Tautin, J. 1976. Population dynamics and harvest of Canada geese in Utah. Thesis. Utah State University, Logan, Utah. (ANALYZED DATA)

Location: Utah State University Library, Logan, UT

Evaluation: Design: 21 years of banding data were studied to determine the distribution and chronology of harvest and effects hunting regulations have had upon harvests and populations parameters. An attempt was made to develop a population model for predicting population trends and survival rates. Timing: 1952 - 1972.

Analysis Methods: Multiple regression analysis, percentages and means were calculated for harvest and recovery data. Annual estimates made statistical comparisons of means of survival & recovery rates, duck stamp sales, and selected regulations. Population modeling.

Value to OIA Study: Conclusions: 78% of annual harvest was taken in northern Utah around the Great Salt Lake marshes. Most of N. Utah harvest are Utah produced peak harvest in S. Utah occur later in season than in N. Utah and more are non-Utah produced. The eastern Utah harvest appears to be mostly dependent on out-of-state produced geese. Before 1950, > 80% of Utah-banded geese recoveries were made in Utah. In 1970's this percentage was reduced to < 50%. Annual survival rates fro 1952-72 showed no significant trend and were comparable to pre-1950 estimates. Only one hunting regulation (daily bag limit) had significant relationship with estimates of annual harvests and band recovery rates. Baseline Data: Some value, although mostly outside study area. Further Study: Recommends continuing study of banding and harvest data. Future analyses of these data should be broadened to consider the effects of hunting regulations and environmental factors throughout the range of the geese.

Subjective Rating of Document: Of value in considering hunting pressures and policy implications.

TEMPO (The Environmental Management Planning Organization). 1982 Environmental assessment: oil and gas lease development. Mt. View, Evanston, and Kamas Ranger Districts. Unpublished, Wasatch-Cache National Forest, Salt Lake City, Utah. (ANALYZED DATA)

Location: Wasatch-Cache N.F. Supervisor's Office, Salt Lake City, Utah.

Evaluation: Design: Contains a brief and qualitative description of wildlife on the North Slope of the Uintas. Impacts of alternatives

are compared in a matrix using three classes: "favorable impact" (defined as little or no effect), "neutral" (moderate habitat disturbance), or "adverse" (impact to critical habitats or sensitive species). Also contains a qualitative discussion of hydrology and a very brief discussion of wetlands and floodplains. Timing: unknown Analysis Methods: qualitative with a matrix.

Value to OIA Study: Conclusions: Preferred alternative would have a "favorable" (little or no effect) impact on wildlife and fish, with five stipulations limiting operations or occupancy. Baseline Data: no value Further Study: Monitoring to verify the conclusions of the EA would be beneficial.

Subjective Rating of Document: The value of this document is for defining USFS management policy for oil and gas development. The brief and qualitative discussion of wildlife and fish seriously limits the value of the EA for wildlife management.

TEMPO (The Environmental Management Planning Organization). 1982. Mt. Naomi Area oil and gas leasing environmental assessment. Unpublished, prepared for the Wasatch-Cache National Forest, Salt Lake City, Utah. (ANALYZED DATA)

Location: Logan Ranger District, Logan, UT, and Wasatch-Cache N.F. Supervisor's Office, Salt Lake City, UT.

Evaluation: Design: Wildlife species occurring, impacts resulting from oil and gas developments and mitigation measures are very briefly discussed. A letter from UDWR is included that states that cutthroat trout in Birch Cr. (T13N, R2E) are hybridized. Timing: unknown Analysis Methods: unknown

Value to OIA Study: Conclusions: Concludes that impacts on wildlife and fish can be avoided by restricting season of operation, avoiding critical habitats, fencing drill sites, and covering reserve pits. Restoration of habitat can avoid cumulative impacts. Includes a list of 29 common species, and indicates sensitive species. Baseline Data: None Further Study: None recommended

Subjective Rating of Document: Brevity and lack of depth seriously limit the value of this document.

Type of Map: Habitat, Species Distribution

Area Covered: National Forest lands in west half of Logan River drainage and all watersheds north and west of Logan River drainage includes parts of Cache CO, Utah and Franklin Co. Idaho.

Scale: 1" = 14,080' or 3/8" = 1 mile

Evaluation: Habitat Types Mapped: Upper limits of deer winter range. Resolution: (Description or Dimension of Smallest Polygon) Deer (migration 1/3 mile, fawning 100-120 acres), elk (migration 1/2 mile,

important habitat 100-120 acres), game birds 50-60 acres, moose 50-60 acres, raptor nesting 50-60 acres.

Evaluation: Species Included: Deer (migration routes and fawning habitat), elk (migration and important habitat), moose habitat, blue grouse, chukar, ruffed grouse and raptor nesting. Distribution from field studies. Year of Original Mapping: 1981 Number of years of Data: unknown Years Updated: none.

Subjective Evaluation of Mapping System: Some value for planning activities on periphery of study area.

Tuttle, M.M. 1975. Public opinion survey of fishing and hunting activities in Utah. UDWR Publication 75-11, Project FW-17-R-2, dated 15 Nov. 75, prepared by the Bureau of Government and opinion Research, Utah State University, Logan, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: Design: Telephone interviews were conducted with 1,000 households Timing: unknown (one-time survey). Analysis

Methods: Percents, means, medians, modes, bi-variant, and multivariant statistical analyses.

Value to OIA Study: Conclusions: unknown - in separate report.

Baseline Data: Could be useful for studies of enforcement problems.

Further Study: See above.

Subjective Rating of Document: Although this document contains no data on wildlife per se it could be valuable in managing law enforcement problems.

U.S. Army Corps of Engineers. 1968, 1974, 1977a, 1977b. Aerial photos. (MAPPING)

Location: USACE Field Office (Sacramento District), 125 South State St., Salt Lake City, UT

Contact Person: Tom Skordall

Type of Map: Aerial Photos

Area Covered: Bear Lake area

Aerial Photos:

Scale: 1:24,000

Date: 1968

Type: B&W

Scale: 1:24,000

Date: 1977

Type: B&W

Scale: 1:6,000

Date: 1974

Type: B&W

Scale: 1:9,600

Date: 1977

Type: Color

Bear River - from National Forest Lands upstream of Evanston to mouth, strip approximately 72,000 feet wide (1 flight path).

Scale: 1:9,6000
Date: Dec. 1981
Type: Color

U.S. Bureau of Land Management. n.d. Management framework plan, Randolph Planning Unit. Unpublished, prepared by BLM, Salt Lake City District, Salt Lake City, Utah. (ANALYZED DATA)

Location: BLM Salt Lake City District Office, Salt Lake City, UT

Contact Person: Jack Brown, Cal McCluskey

Evaluation: Design: Management Plan. Timing: N.A.

Value to OIA Study: Conclusions: States management decisions regarding wildlife on BLM lands. Relevant decisions include: (1.1) Livestock exclosures will be constructed on some streams, further study streams are specified. (1.2 and 1.4) specifies shrub/forb/grass composition objectives for deer winter range, sage grouse breeding and critical deer winter range, and all other lands. (1.6) Exclosures may be used to benefit marsh hawk, short-eared owls, rabbits, and for study plots. (2.1) Waterfowl will be maintained. (2.2) Seismic exploration restricted in mule deer winter range 15 Nov. - 30 Apr., surface disturbance prohibited in grouse strutting grounds 1 Apr. - 15 June, road construction, seismic exploration, and well development prohibited within 600' of riparian zones. (2.3) Maintain raptor nesting habitat by restricting disturbing activities within 1/2 mile of active nests 1 Mar. - 30 June. (2.4 and 2.5) Adjust and/or restrict grazing to be compatible with wildlife. (3.1) Cooperate with UDWR to reintroduce antelope. (3.2) No warm-water fishery and no public access will be provided at Neponset Reservoir. Baseline

Data: NA Further Study: NA

Subjective Rating of Document: Allows broad-scope assessment of BLM direction in wildlife management.

U.S. Bureau of Land Management. n.d. Randolph Planning Unit grazing management environmental statement final. Unpublished, prepared by BLM Salt Lake City District, Salt Lake City, Utah. (ANALYZED DATA)

Location: BLM, Salt Lake District, Salt Lake City, UT.

Evaluation: Design: Forage allocations for livestock and wildlife forage needs were compared. Design for fisheries is unclear.

Timing: Range evaluations: 1976-1978, wildlife: 1978 only.

Fisheries: not specified. Analysis Methods: Forage allocated to livestock and wildlife were subtracted from available forage for each of 6 alternatives. Continued degradation of fisheries was assumed if livestock grazing continued, based on literature and the Big Creek exclosure.

Value to OIA Study: Conclusions: Preferred alternative will result in significant shortfalls of forage for wildlife and continued degradation of fisheries. Baseline Data: Data on range conditions may have some value, but averaging and other manipulations reduce that value. Further Study: Has potential for study of wildlife/livestock interactions which are peripheral to oil and gas development.

Subjective Rating of Document: Good background information for wildlife/livestock interactions.

Other Comments: Concentrates on deer, sage grouse, and fisheries. Appendices 5, 6, 10, 11, 12, 17, 18, 19, and 20 contain useful information detailing findings or methods summarized in the text.

Type of Map: Species distribution

Area Covered: southeastern Rich County

Evaluation(Species Occurrence Maps): Scale: 1" = 25,545' Species

Included: Sage Grouse, Mule Deer Years Updated: none

Subjective Evaluation of Mapping System: Other BLM documents imply that other unknown sage grouse leks may exist, and the map only covers leks, limiting its value.

U.S. Bureau of Land Management. n.d. Unit resource analysis, step 3. Unpublished, prepared by BLM Salt Lake City District, Salt Lake City, Utah. (ANALYZED DATA)

Location: BLM Salt Lake City Office.

Evaluation: Design: Qualitative discussions of wildlife management supported by statistics when available. Deer: include historical hunting statistics, narrative descriptions of current and potential populations from UDWR, descriptions of present and future seasonal forage, demands and conditions of browse by allotment, water availability, cover availability, livestock interactions including photographic documentation of mortality caused by fences, and habitat change or loss. Elk: seasonal ranges, food, water, cover, harvests, and a brief discussion of conflicts. Moose: food, water, cover, important use areas, and a brief discussion of habitat change or loss. Black bear, mountain lion, bobcat, coyote, beaver, mink, otter, and marten are briefly discussed. Antelope habitat change or loss and transect and harvest data for hares and rabbits are briefly discussed. Sage grouse: seasonal areas, food, cover, habitats, important use areas, special use areas, conflicts and habitat loss, and harvests are discussed. Forest grouse, chukar, and Hungarian partridge are briefly discussed. Raptors: food, habitat areas, and important use area data is included. Waterfowl and sandhill crane: use, numbers, harvest species, and conflicts are discussed. Reptiles and amphibians are briefly discussed. Riparian areas and fisheries data is presented by

stream. Appendices include small mammal trapping results and browse transect field data. Timing: variable. Analysis Methods: Generally qualitative except for discussions of forage and recreation supplies and demands.

Value to OIA Study: Conclusions: Refer to Randolph ES, this study provides detailed background for that document. Baseline Data: value is variable. Further Study: Some items may be worth further study.

Subjective Rating of Document: This document is very valuable for background information and as a collection of wildlife information.

Type of Map: Habitat

Area Covered: Randolph Planning Unit (public and private lands)

Scale:: 1" = 1 mile.

Evaluation: Habitat Types Mapped: Deer winter range (upper limits, lower limits, severe winter) deer migration routes, deer pellet group transect, chukar habitat, sage grouse strutting grounds, and raptor nests with dates. Resolution: Upper limits of deer winter range: 70-80 acres, lower limits of deer winter range: 15-20 acres, deer severe winter range: 5-10 acres, chukar: 700-800 acres, sage grouse strutting grounds: 450-500 acres. Ground Truthed? Yes. Year Updated: unknown.

Subjective Evaluation of Mapping System: UDWR base map supplemental with additional field observations. See UDWR map evaluation.

U.S. Bureau of Land Management. 1981. Wildlife annual report. Unpublished report, prepared by Utah State Office, Salt Lake City, Utah. (ANALYZED DATA)

Location: BLM Utah State Office, Salt Lake City

Evaluation: Design: Contains both state-wide and district-wide summaries of wildlife management activities. Timing: Cumulative. Analysis Methods: Totals are calculated.

Value to OIA Study: Conclusions: none Baseline Data: This document could be used to compare current and past wildlife management activities. Further Study: none recommended.

Subjective Rating of Document: This document has some value for describing management activities, but contains relatively little data on the wildlife itself.

U.S. Bureau of Land Management. 1982. Price River grazing management draft environmental impact statement. Unpublished, prepared by Price River Resource Area Office, Price, Utah. (ANALYZED DATA)

Location: USDI BLM Price River Resource Area Office, Price, UT

Evaluation: Design: Current populations of deer, elk, moose, antelope, and bighorn sheep are compared with historic stable populations. Data on current deer populations are based on UDWR

pellet group transect data, others are based on UDWR seasonal use acreage/ animal estimates, and SVIM (soil-vegetation inventory method) data. Historic population data are UDWR estimates. Population numbers are broken down by allotment, type of range, and species. Forage needs are based on a linear programming computer model. Timing: Unknown, but based on comparison of current and historic population levels. Analysis Methods: Impacts of alternatives are discussed in terms of the numbers of allotments with forage shortfalls and season of use for big game, upland game, vegetation types, and fisheries.

Value to OIA Study: Conclusions: Some allotments would continue to have forage shortfalls, fisheries would decline unless protected, and some vegetation type conditions would decline. Baseline Data: No value - not in study area. Further Study: Some method used in this EIS could be applied to the study area.

Subjective Rating of Document: Main values are for identification of wildlife-grazing conflicts and for suggesting method to measure impacts. Impacts are not tabulated as well as the Randolph ES.

U.S. Bureau of Reclamation. 1975. Environmental assessment Weber Basin Project, water sales contracts, East Canyon-Parley's Park, Snyderville Basin Project. Unpublished (see comment) dated March 75. (ANALYZED DATA)

Location: Unknown - see comment.

Evaluation: Design: Includes a habitat matrix showing seasonal status, cover types used, elevation used, nesting habitats and abundance of birds. Timing: unknown. Analysis Methods: unknown.

Value to OIA Study: Conclusions: unknown. Baseline Data: unknown. Further Study: unknown.

Subjective Rating of Document: Could contain a useful tool in the form of the habitat matrices which are detailed.

Comment: This document was cited in Bingham Engineering (1982) and 11 pages were reproduced. However, USBR in Salt Lake City has no records indicating that this document was ever prepared.

U.S. Bureau of Reclamation. 1975. Final environmental statement, completion of Lyman Project Wyoming-Utah. Unpublished, dated 8 Dec. 75. (ANALYZED DATA)

Location: U.S. Bureau of Reclamation, Salt Lake City.

Evaluation: Design: Contains compilations of studies by USFS, UDWR, and WGFD: electroshocking; pellet group counts; beaver, elk, and moose counts; flow calculations; water quality measurements, and invertebrate sampling. Timing: varies. Analysis Methods: Percent rates and averages were computed, fish

coefficients of conditions were calculated, standing crops were extrapolated.

Value to OIA Study: Conclusions: Concludes that construction of the project would have short-term adverse impacts on fish and wildlife, mixed effects on fish in the long-term, and adverse effects (loss of habitat) on wildlife. Baseline Data: Valuable for the project area. Further Study: Further study would be worthwhile if oil and gas operations take place in the area.

Subjective Rating of Document: This document contains one of the better fish and wildlife sections encountered in an environmental statement.

U.S. Fish and Wildlife Service. n.d. Computer printout of GIS contents.

Unpublished data, USFWS, Salt Lake City. (RAW DATA)

Location: U.S. Fish and Wildlife Service, Salt Lake City.

Contact Person: Clark Johnson, George Bowen.

Evaluation: Design: Computer printout listing computer identification, common name, and sources of maps in USFWS GIS. Source data includes keywords, contact persons, vintage, medium and accuracy. Timing: varied. Anticipated Completion Date: ongoing.

Value to OIA Study: Geographic Area Covered: Various parts of Utah. Further Study: Additional maps could be digitized and entered into the system. Potential For Use in Wildlife Management: Could be very valuable due to time saving capability at the computer, but relatively few maps are relevant to the study area.

Subjective Rating of Document: The list of maps has some value but the source data is more useful.

U.S. Fish and Wildlife Service. n.d. Kuchler potential vegetation maps.

Unpublished maps, stored on USFWS computer, Salt Lake City, Utah. (MAPPING).

Location: U.S. Fish and Wildlife Service, Salt Lake City, Utah.

Contact Person: Clark Johnson, George Bowen.

Type of Map: Habitat

Area Covered: all of Utah.

Scale: variable, originally 1:1,000,000

Evaluation: Habitat Types Mapped: Arizona pine forest, barren alpine meadow, black brush, douglas-fir forest, foothills prairie, great basin sagebrush with juniper, great basin sagebrush, golletta 3 awn shrub steppe, mountain mahogany - oak shrub, pine douglas-fir forest, pinyon juniper woodland, sagebrush steppe, spruce-fir douglas-fir forest, salt brush-greasewood, southwest spruce-fir

forest, oak-juniper woodland mountain mahogany-oak scrub, wheatgrass-bluegrass, and western spruce-fir forest. Resolution: cell size is 220 acres. Ground Truthed? unknown.

Evaluation: Year of Original Mapping: 1979.

Subjective Evaluation of Mapping System: Value is limited by the large scale of the vegetation map.

U.S. Fish and Wildlife Service. n.d. UDWR state-wide wildlife maps.

Unpublished maps, stored on USFWS computer, Salt Lake City, Utah.

Location: U.S. Fish and Wildlife Service, Salt Lake City, Utah.

Contact Person: Clark Johnson, George Bowen.

Type of Map: Species Distribution

Area Covered: All of Utah

Scale: variable, originally 1:1,000,000.

Evaluation: Resolution: cell size is 220 acres. Ground Truthed? unknown. Species Included: Antelope, black-tailed ferret, blue grouse, chukar, California quail, cottontail deer, mouse, elk, greater shrew, Hungarian partridge, lynx, mule deer (normal and severe winter range) mourning dove, mink, moose, muskrat, river otter, ring-necked and white-winged pheasant, marten, ruffed grouse, sage grouse, snowshoe hare, sharp-tailed grouse, white pelican, and wolverine (partial list - includes only species which may be in the study area). Inferred Distribution - some. Distribution From Field Studies - some. Year of Original Mapping: varies. Years Updated: none.

Number of Years of Data: unknown

Subjective Evaluation of Mapping System: Not as useful as the UDWR regional maps, but these maps do include some data not on the regional maps.

Comments: Additional source information on printout indicates that: the original medium is mylar/acetate, accuracy is high, and the UDWR contact is Ed Rawley.

U.S. Fish and Wildlife Service. 1981. U-2 infrared photography. Unpublished. Photography being done for MX Missile. (MAPPING)

Location: USFWS National Wetlands Inventory Team, Denver, CO.

Contact Person: Chuck Elliot

Area Covered: All of Rich County and part of Summit County.

Aerial Photos: Scale: 1:65,000. Date: June 1981. Type:

Infrared. U-2 9x9 contacts.

Comment: These photos are being used for wetlands mapping in the Great Salt Lake Valley by UDWR, USACE, and USFWS. SCS has expressed interest in mapping lower Bear River with these photos.

U.S. Fish and Wildlife Service. Utah threatened and endangered species map. Unpublished document, prepared by USFWS Endangered Species Office, Salt Lake City, Utah. (MAPPING)

Location: USFWS Endangered Species Office, 125 South State Street, Salt Lake City, UT.

Contact Person: Bob Benton.

Type of Map: Species Distribution (overlay).

Area Covered: All of Utah.

Scale: 1:500,000

Evaluation: Species Included: Utah prairie dog, black-footed ferret, peregrine falcon, whooping crane, bald eagle, humpbacked chub, bony-tailed chub, woundfin, Colorado squawfish, Lahontan cutthroat, and desert tortoise. Virgin River roundtail chub is included, proposed for listing. Eight Threatened and Endangered plants are also included - contact Larry England. (none in study area) Years of Original Mapping: unknown. Years Updated: unknown. Number of Years to Date: unknown.

Subjective Evaluation of Mapping System: Some value for preliminary identification of sensitive areas, but value is limited by gross scale and resolution.

U.S. Forest Service. n.d. Wasatch National Forest Stream Catalogue unpublished report. Wasatch-Cache National Forest, Salt Lake City, Utah. (RAW DATA)

Location: Wasatch-Cache NF Supervisor's Office, Salt Lake City, Utah.

Contact Person: Mark Shaw.

Evaluation: Design: Streams are arranged by drainage, unlike UDWR printout. Data includes state catalogue number, site class, Ranger District, length to nearest 0.1 mile, productivity class (1 worst - 5 best), game fish species present (rainbow trout, cutthroat trout, Colorado cutthroat trout, brook trout, whitefish), and fishery value class (I, II, III, IV, and unsurveyed). Timing: unknown.

Anticipated Completion Date: NA.

Value to OIA Study: Geographic Area Covered: All of Wasatch-Cache NF.

Baseline Data: From UDWR data, standardized methods were used.

Further Study: Dates of surveys unknown, old surveys could be updated. See also attached stream surveys. Potential For Use in Wildlife Management: Useful for evaluating impacts and for identifying sensitive fisheries.

Subjective Rating of Document: Valuable if used in conjunction with UDWR maps.

U.S. Forest Service. n.d. Stream survey data. Unpublished documents supplementing USFS n.d. Wasatch National Forest Stream Catalogue. Wasatch-Cache NF, Salt Lake City, Utah. (RAW DATA)

Location: Supervisor's Office, Wasatch-Cache NF, Salt Lake City, Utah.

Contact Person: Mark Shaw.

Evaluation: Design: Field reconnaissance was used to collect data on streams - see potential for use. Timing: unknown. Anticipated Completion Date: ongoing.

Value to OIA Study: Geographic Area Covered: Green River tributaries: East Fork Smiths Fork*, Little West Fork Blacks Fork*, Middle Fork Blacks Fork*; Logan River and Temple Fork; Bear River tributaries: Sugarpine Creek*, Mill Creek*, Carter Creek*, McKenzie Creek*, North Fork Mill Creek*, West Fork Bear River*, Meadow Creek*; Weber River tributaries: Beaver Creek*, East Fork Moffit Creek*; Jordan River tributaries: Little Cottonwood Creek, Big Cottonwood Creek, Mill Creek; Provo River tributaries: North Fork Provo River*, and Broadhead Meadows Creek* (*in OIA study area). Baseline Data: Data is collected in standardized manner. Further Study: Supplements UDWR data. Burnt Fork (tributary to Green River) will be surveyed next fiscal year. Potential For Use in Wildlife Management: Data on aquatic vegetation, beaver use, geologic landform, valley bottom width, riparian zone width, and fish habitats supplements UDWR data.

Subjective Rating of Document: Useful supplements to UDWR data.

U.S. Forest Service. 1968. Multiple use survey for the development and improvement of the North Rich Cattle Allotment. Unpublished report, prepared by Randolph Ranger District, Cache NF. (ANALYZED DATA)

Location: Logan Ranger District, Logan UT.

Contact Person: Stan Miller.

Evaluation: Design: Qualitative discussion of sage grouse and deer and the absence of fisheries. Briefly discusses herbicide vs. sage grouse. Timing: unknown.

Value to OIA Study: Baseline Data: Not repeatable. Further Study: none recommended.

Subjective Rating of Document: Very little value to OIA.

U.S. Forest Service. 1980. Jebo Creek Timber Sale Environmental Assessment. Unpublished, dated 18 August 80, prepared by Logan Ranger District Wasatch-Cache National Forest, Logan Utah. (ANALYZED DATA).

Location: Logan Ranger District, Logan, UT.

Contact Person: District Ranger, Logan Ranger District, Logan, UT.

Value to OIA Study: Geographic Area Covered: Portion of Logan Ranger District. Baseline Data: not repeatable. Further Study: none recommended. Potential for Use in Wildlife Management: Little potential, includes a list of 18 mammals and 29 birds found in the area.

Subjective Rating of Document: Little or no value to OIA.

U.S. Forest Service. 1981. Oil and gas stipulations maps. Unpublished maps, Wasatch-Cache National Forest. Salt Lake City, Utah. (MAPPING)

Location: Wasatch-Cache NF Supervisor's Office.

Evaluation: Habitat Types Mapped: Riparian areas and municipal watersheds (riparian zone map) and elk calving and other key habitat (wildlife map). Resolution: Riparian area: 25-30 acres, municipal watershed: 50-60 acres, elk calving: 200-500 acres, other key habitat: 90-120 acres, unique fish 1/2 mile stream reaches.

Evaluation: Species Included: Utah cutthroat trout and Colorado cutthroat trout (unique fish species map), Distribution: from Field Studies.

Subjective Rating of Document: Better maps can be found for wildlife management, the main value is for use with USFS stipulation overlays.

U.S. Forest Service. 1981. Region 4 wildlife and fish assessment data base for the 1980 regional plan. Unpublished report, dated August 1981, USFS Intermountain Region, Ogden Utah.

Location: Regional Office, USFS Intermountain Region, Ogden, Utah.

Evaluation: Design: Compilation of statistics and goals: occurrence of harvest species and threatened and endangered species (by Forest); state by state list of sensitive plants and animals (this table is not accurate - indicates no T&E animals on the Wasatch-Cache); habitat indicator species list; situation tables for elk, mule deer, moose, black bear, sage grouse, blue grouse, chukar, and fisheries showing acres of NF habitat; % of total habitat on NFs and state-wide, percent population estimates, hunter-days on NFs, dollar value, and goals. Also contains an explanation of the Biological Conditions Index used for streams. Timing: unknown. Analysis Methods: Totals, percents, and averages are calculated.

Value to OIA Study: Conclusions: Conclusions are expressed as targets which the Wasatch-Cache Analysis of the Management Situation (USFS 1982) concluded were unattainable. Baseline Data: Little value due to the scale of the information. Further Study: None recommended.

Location: Utah State University Library, Logan UT.

Subjective Rating of the Document: Most of the document is statistics, of little value, but the explanation of the Biological Condition Index could be useful

U.S. Forest Service. 1982. Wildlife and fish: Analysis of the management situation for Forest planning. Unpublished report, dated April 1982, prepared by Wasatch-Cache NF. Salt Lake City, Utah. (ANALYZED DATA)

Location: Wasatch-Cache NF Supervisor's Office, Salt Lake City, Utah.

Evaluation: Design: Management indicator species are selected and placed in two groups - ecological indicators (14 species and 1 species group) and emphasis species (7 species). Habitat requirements for these and seven sensitive species are discussed. Inventory of acres of current and potential habitat and estimated rates of changes are given for terrestrial species. Aquatic habitats are broken into 4 gradient classes and average Community Tolerance Quotients and Biological Condition Factors are given for each class. Habitat Condition Indices are given for fishes of special interest. Problem areas are identified and habitat improvement needs are quantified. Diversity indices (Baxter-Wolfe Interspersion) are given for 16 of 17 management areas on the Forest. Acres of riparian habitat (willow and wet meadow) are tabulated and rated (good, fair, poor). Wildlife management objectives of UDWR and WG&F are discussed relative to Forest Service practices. Demand for wildlife is determined through UDWR and USFS RIM data. Regional and Forest goals and objectives and issues and concerns are listed. Timing: Stream habitat Community Tolerance Quotients based on 300 + samples taken since 1978. Others unknown. Analysis Methods: varied - see design.

Value to OIA Study: Conclusions: The Wasatch-Cache ranks first or second of National Forests in Utah in public use of game species and first or second for populations of elk, deer, moose, and mountain goat. Regional targets cannot be met because of funding and/or technical or physical constraints. Programs and funding techniques for achieving targets are limited. Baseline Data: Little value due to the large area covered, but some data is specific to smaller areas. Further Study: 18 items are listed in the document.

Subjective Rating of Document: Very useful for understanding management direction and overall condition on the Forest. Major limitation is the large geographic area that most data describes.

U.S. Forest Service. 1982. Fisheries maps. Unpublished maps, prepared by Wasatch-Cache National Forest, Salt Lake City, Utah.

Location: Wasatch-Cache NF Supervisor's, 125 South State Street, Salt Lake City

Contact Person: Mark Shaw

Type of Map: Habitat (overlay)

Scale: 1:24000

Evaluation: Habitat Types Mapped: Four stream gradient classes (0-1.3%, 1.4-2.0%, 2.1-3.0, and over 3.0%), ephemeral/perennial streams, and state stream class. Resolution: 0.1 mile. Ground Truthed? yes.

Number of Seasons: unknown.

Subjective Evaluation of Mapping System: Main value is a graphic display of some data contained in UDWR and USFS documents. This is apparently the only document with gradients specified for individual streams.

U.S. Forest Service. 1982. Wildlife maps. Unpublished maps, prepared by Wasatch-Cache National Forest, Salt Lake City, Utah. (ANALYZED DATA)

Location: Wasatch-Cache National Forest Supervisor's Office, Salt Lake City.

Contact Person: Jim Cole

Type of Map: Habitat, Species Distribution (overlays)

Area Covered: All Wasatch-Cache NF lands.

Scale: 1:24,000

Evaluation: Habitat Types Mapped: Mule deer winter range, elk (winter range and non-winter range), and moose (winter range and non-winter range). Resolution: 1 acre or less. Grounds Truthed? Unknown.

Evaluation: Species Included: Mountain goat (none in study area), bald eagle (wintering areas and roosts), peregrine falcon, and Bonneville cutthroat trout. Distribution from Field Studies. Year of Original Mapping: 1982. Years Updated: 0. Number of Years of Data: unknown.

Subjective Evaluation of Mapping System: Very valuable for identifying sensitive areas with high resolution, but limited to National Forest Lands.

U.S. Geological Survey. n.d. Development of Coal Resources in Southern Utah, Part 1 Regional Analysis, Draft Environmental Statement. (no publication information) (ANALYZED DATA)

Location: Utah State University Library, Logan UT.

Evaluation: Design: Brief discussions of the status of a variety of species found in the area are provided. Herd units associated vegetation types, hunting pressure and harvest data are tabulated. Highway mortality is discussed in terms of numbers and species affected. Impacts are discussed in terms of habitat loss.

Timing: unknown. Analysis Methods: Extrapolation.

Value to OIA Study: Conclusions: Conclusions are based on quantified habitat loss and similar factors, but activities associated with impacts are discussed grossly, limiting the overall value. Baseline Data: Little or no value. Further Study: None recommended.

Subjective Rating of Document: Relatively little value except for comparison of coal mining impacts and oil and gas development on a gross scale.

U.S. Soil Conservation Service. in preparation. Soil survey of Summit County Utah. (RAW DATA)

Location: U.S. Soil Conservation Service, Provo, UT

Contact Person: Ed Burton

Evaluation: Design: Standard SCS methods including text and tables describing wildlife capabilities of soils. Timing: unknown.

Anticipated Completion Date: 1983.

Value to OIA Study: Geographic Area Covered: Summit County.

Baseline Data: Repeatable, but very little value for baseline purposes as soil types are unlikely to change. Further Study:

None recommended. Potential For Use in Wildlife Management:

Valuable to guide facilities siting and to assist in reclamation.

Subjective Rating of Document: Will be valuable for identifying limitations of soils and guiding mitigation projects.

Upper Colorado Region State-Federal Inter-agency Group. 1971. Upper Colorado region comprehensive framework study. Appendix XIII Fish and Wildlife. Unpublished report, dated June 1971. (ANALYZED DATA)

Location: U.S. Soil Conservation Service. Salt Lake City (Library copy only).

Evaluation: Design: Includes discussion of existing (1965) supply and demand for fish and wildlife, future supply and demand, projected unmet demands, and means to meet demands compiled by a large number of agencies. Timing: unknown. Analysis Methods: compilation of existing and projected program targets.

Value to OIA Study: Conclusions: Makes general recommendations for wilderness, reservoirs, restoration of natural lakes, fisheries, range, vegetation manipulation, planning, wildlife management, mining, flood control, and drainage projects. Baseline Data:

Little value due to the scale. Further Study: None recommended.

Subjective Rating of Document: Provides a useful regional context but is outdated.

Utah Division of Wildlife Resources. in preparation. Elk maps. Unpublished maps prepared by UDWR Regional Office, Ogden, Utah. (MAPPING)

Location: UDWR Northern Regional Office, 513 East 5300 South, Ogden, UT.

Contact Person: George Wilson, Cathy Denny

Type of Map: Species Distribution, (overlay).

Area Covered: Rich and Cache Counties (1 map), Summit County (1 map), others covering remainder of Northern Region.

Scale: 1" = 10560' 1/2" = 1 mile.

Evaluation: Resolution: 30-40 acres except for migration routes.

Migration routes may extend 3 miles to either side of indicated routes.

Evaluation: Species Included: Elk: winter range (normal and critical), summer range, calving areas, herd boundaries, and migration routes. Distribution from field studies. Year of Original

Mapping: in progress. Years Updated: NA. Outdated Marks

Removed? NA. Number of Years of Data: unknown.

Subjective Evaluation of Mapping System: Very useful for identifying critical/sensitive areas. Some limitation imposed by basis of data - see comments.

Comment: Maps are based on years of observation by UDWR staff, some observers on staff over 15 years. Summit County map will be revised by incorporating telemetry data, but Rich County map will still be based on observation. Slope and aspect were used to refine field observations. Critical winter range is based on observations during harsh winters. Overlays on BLM map showing land ownership.

Utah Division of Wildlife Resources. in preparation. Fisheries and aquatics habitats maps. Unpublished maps, prepared by UDWR Regional Offices (Ogden, Utah). (MAPPING)

Location: UDWR Northern Regional Office, 513 East 5300 South, Ogden, Utah

Contact Person: George Wilson, Cathy Denny

Type of Map: Habitat, Species Distribution.

Area Covered: Rich and Cache Counties (1 map). Summit County (1 map), others covering remainder of Northern Region.

Scale: 1" = 10560', 1/2" = 1 mile.

Evaluation: Habitat Types Mapped: cold/warm water fishery, ranking (crucial - critical, high priority, substantial value, limited value), stream class (from statewide fisheries computer printout) and need for year-round protection. Above entered for stream reaches and lakes. Dewatered stream reaches and comments on conflicts are mapped. Also includes other aquatic habitats: stock ponds, springs, improved springs, seeps, wells and guzzlers.

Evaluation: Species Included: all stocked fishes, and other species - 67 total state-wide. Distribution from field studies. Years of Original Mapping: in progress. Years Updated. NA.

Subjective Evaluation of Mapping System: Very valuable for baseline and evaluation of critical/sensitive areas. Good-excellent potential for use in GIS and DBMS.

Comment: Overlays on BLM map showing land ownership.

Utah Division of Wildlife Resources. in preparation. Furbearer maps. Unpublished maps, prepared by UDWR Regional Offices (Ogden, Utah). (MAPPING)
Location: UDWR Northern Regional Office, 513 East 5300 South, Ogden, Utah.

Contact Person: George Wilson, Cathy Denny

Type of Map: Habitat, Species Distribution (overlay).

Area Covered: Rich and Cache Counties (1 map). Summit County (1 map), others covering remainder of Northern Region.

Scale: 1" = 10560', 1/2" = 1 mile.

Evaluation: Habitat Types Mapped: Beaver habitat (shows year surveyed, gross suitability based on stream gradient, valley width, and parent material, acres of aspen, and acres of willow. Marten - coniferous forest. River otter - coniferous forests. Resolution: Beaver and otter 120-130 acres, marten 10,000-20,000 acres. Ground Truthed? No.

Evaluation: Species Included: Beaver, marten, river otter, and ring-tailed cats (no ring-tails in study area). Kit fox being considered for inclusion. Distribution inferred and from field studies - see comments. Year of Original Mapping: in progress. Years Updated. NA. Number of Years of Data: unknown.

Subjective Evaluation of Mapping System: Useful for beaver, usefulness for other species is limited to inferred distribution, lack of comprehensive surveys and resolution.

Comment: Beaver habitat based on UDWR aerial surveys, marten habitat based on coniferous forest, river otter based on coniferous forest and sightings. Overlays on BLM map showing land ownerships.

Utah Division of Wildlife Resources. in preparation. Grazing allotment maps. Unpublished maps, prepared by UDWR Regional Offices (Ogden, Utah). (MAPPING)

Location: UDWR Northern Regional Office, 513 East 5300 South, Ogden, Utah 84403.

Contact Person: George Wilson, Cathy Denny

Type of Map: Species Distribution (overlay).

Area Covered: Rich and Cache Counties (1 map). Summit County (1 map), others covering remainder of Northern Region.

Scale: 1" = 1-560' or 1/2" = 1 mile.

Evaluation: Habitat Types Mapped: BLM and USFS grazing allotments.

Year of Original Mapping: in progress. Years Updated: NA.

Subjective Evaluation of Mapping System: This map's main value is the compilation of USFS and BLM grazing allotments on a single map.

Comment: Overlays on BLM map showing land ownership.

Utah Division of Wildlife Resources. in preparation. Habitat manipulation maps. Unpublished maps, prepared by UDWR Regional Offices (Ogden, Utah). (MAPPING)

Location: UDWR Northern Regional Office, 513 East 5300 South, Ogden, Utah.

Contact Person: George Wilson, Cathy Denny

Type of Map: Habitat, (overlay).

Area Covered: Rich and Cache Counties (1 map). Summit County (1 map), others covering remainder of Northern Region.

Scale: 1" = 10560' or 1/2" = 1 mile.

Evaluation: Habitat Types Mapped: Spray (herbicide) projects, controlled burns and wildfires, seedings, aspen thinning, aspen clearcutting, willow plantings, mountain mahogany pruning, and water developments (springs, improved springs, wells, ponds or reservoirs, water troughs, pipelines, guzzlers, and seeps). Dates of spray projects and burns are indicated by year. Resolution: Burns are symbolized in 5 acreage classes: 1-9 acres, 10-99 acres, 100-299 acres, 300-999 acres, and over 1000 acres. Ground Truthed? Unknown.

Evaluation: Years of Original Mapping: in progress. Years Updated: NA. Number of Years of Data: unknown.

Subjective Evaluation of Mapping System: Main value of these maps is the compilation of different agencies' activities on one map and for identification of where investments in wildlife habitat have been made.

Comment: Includes projects undertaken by USFS, BLM, and SCS. Overlays on BLM map showing land ownership.

Utah Division of Wildlife Resources. in preparation. Historical occurrences and conflicting developments maps. Unpublished maps, prepared by UDWR Regional Offices (Ogden, Utah). (MAPPING)

Location: UDWR Northern Regional Office, 513 East 5300 South, Ogden, Utah.

Contact Person: George Wilson, Cathy Denny

Type of Map: Overlay.

Area Covered: None prepared for study area.

Scale: 1" = 10560' or 1/2" = 1 mile.

Subjective Evaluation of Mapping System: Could have limited value for planning.

Comment: The historical occurrence maps show historical locations of various species. The conflicting developments maps show mines (coal and non-coal) and other industrial sites conflicting with wildlife.

Utah Division of Wildlife Resources. in preparation. Introduction and expansions maps. Unpublished maps, prepared by UDWR Regional Offices (Ogden, Utah). (MAPPING)

Location: UDWR Northern Regional Office, 513 East 5300 South, Ogden, Utah.

Contact Person: George Wilson, Cathy Denny

Type of Map: Species Distribution, Overlay.

Area Covered: Rich and Cache Counties. None prepared for Summit County.

Scale: 1" = 10560' or 1/2" = 1 mile.

Evaluation: Species Included: Bald eagle and peregrine falcon back sites. Distribution from field studies. Years of Original

Mapping: in progress. Years Updated. NA. Number of Years of Data: unknown.

Subjective Evaluation of Mapping System: Useful for identifying sensitive sites.

Comment: Overlays on BLM map showing land ownership.

Utah Division of Wildlife Resources. in preparation. Moose maps. Unpublished maps, prepared by UDWR Regional Offices (Ogden, Utah). MAPPING.

Location: UDWR Northern Regional Office, 513 East 5300 South, Ogden, Utah.

Contact Person: George Wilson, Cathy Denny

Type of Map: Habitat, Species Distribution, Overlay.

Area Covered: Rich and Cache Counties (1 map), Summit County (1 map), others covering remainder of Northern Region.

Scale: 1" = 10560' or 1/2" = 1 mile.

Evaluation: Habitat Types Mapped: Critical value moose range (critical use areas and population distribution) based on elevation, browse transects, and locations of willow bottoms. Resolution: winter range 30-40 acres, calving 120-130 acres, others 500 acres. Ground truthed? Yes. Number of seasons: Unknown.

Evaluation: Species Included: Moose (critical value - see above, winter range - critical and normal, calving areas, summer range, yearlong range, and herd distribution. Distribution from field studies. Years of Original Mapping: in progress. Years Updated: NA. Numbers of Years of Data: unknown.

Subjective Evaluation of Mapping System: Very useful for identifying critical/sensitive areas. Some limitations imposed by resolution and basis of data - see comments.

Comments: Designation of critical value moose range is somewhat arbitrary. Calving range has been well determined. This map is also based on field observations, not telemetry. Overlays on BLM map showing land ownerships.

Utah Division of Wildlife Resources. in preparation. Mule deer maps. Unpublished maps, prepared by UDWR Regional Offices (Ogden, Utah). (MAPPING)

Location: UDWR Northern Regional Office, 513 East 5300 South, Ogden, Utah.

Contact Person: George Wilson, Cathy Denny

Type of Map: Species Distribution (overlay).

Area Covered: Rich and Cache Counties (1 map), Summit County (1 map), others covering remainder of Northern Region.

Scale: 1" = 10560' or 1/2" = 1 mile.

Evaluation: Habitat Types Mapped: seasonal ranges. Resolution: 30-40 acres. Ground Truthed? Yes. Number of Seasons? unknown.

Evaluation (Species Occurrence Maps): Species Included: Mule deer (winter range - critical and normal, summer range - critical and normal, fawning range, year-long range, migration routes, and herd units). Distribution from field studies. Year of Original Mapping: in progress. Years Updated. NA. Outdated Marks Removed? NA. Number of Years of Data: unknown.

Subjective Evaluation of Mapping System: Very useful for identifying critical/sensitive areas. Some limitation imposed by basis of data - see comments.

Comment: Maps are based on years of observation by UDWR staff, some observers on staff over 15 years, but no telemetry. Slope and aspect were used to refine field observations. Critical winter

range is based on observations during harsh winters. Overlays on BLM base map showing land ownerships.

Utah Division of Wildlife Resources. in preparation. Predator map. Unpublished maps, prepared by UDWR Regional Offices (Ogden, Utah). (MAPPING)

Location: UDWR Northern Regional Office, 513 East 5300 South, Ogden, Utah.

Contact Person: George Wilson, Cathy Denny

Type of Map: Species Distribution, (overlay).

Area Covered: Rich and Cache Counties (1 map), Summit County (1 map), others covering remainder of Northern Region.

Scale: 1" = 10560', 1/2" = 1 mile.

Evaluation: Resolution: 10,000 - 20,000 acres. Ground Truthed? Unknown.

Evaluation: Species Included: Black bear, cougar, and lynx (population distribution and year-long range for each). Years of Original Mapping: in progress. Years Updated: NA.

Numbers of Years to Date: unknown.

Subjective Evaluation of Mapping System: Usefulness is limited by the resolution.

Comment: Overlays on BLM map showing land ownerships.

Utah Division of Wildlife Resources. in preparation. Raptor maps.

Unpublished maps, prepared by UDWR Regional Offices (Ogden, Utah). (MAPPING)

Location: UDWR Northern Regional Office, 513 East 5300 South, Ogden, Utah.

Contact Person: George Wilson, Cathy Denny

Type of Map: Species Distribution, (overlay).

Area Covered: Rich and Cache Counties (1 map), Summit County (1 map), others covering remainder of Northern Region.

Scale: 1" = 10560 or 1/2" = 1 mile.

Evaluation: Species Included: Bald eagle (winter concentrations), eyries nests of golden eagle, ferruginous hawk, red-tailed hawk, prairie falcon, and great horned owl. Distribution from field studies. Years of Original Mapping: in progress. Years Updated: NA. Number of Years of Data: unknown.

Subjective Evaluation of Mapping System: Useful for identifying sensitive areas. Some limitation imposed by limited resolution and lack of comprehensive survey.

Comment: Actual sightings plotted to $\pm 1/2$ inch (1 mile). Overlays on BLM maps showing land ownership.

Utah Division of Wildlife Resources. in preparation. Shorebirds maps.

Unpublished maps, prepared by UDWR Regional Offices (Ogden, Utah). (MAPPING)

Location: UDWR Northern Regional Office, 513 East 5300 South, Ogden, Utah.

Contact Person: George Wilson, Cathy Denny

Type of Map: Species Distribution (overlay).

Area Covered: Rich and Cache Counties (1 map), Summit County (1 map), others covering remainder of Northern Region.

Scale: 1" = 10560" or 1/2" = 1 mile.

Evaluation: Resolution: 70 - 80 acres. Ground Truthed? Yes.
Number of Seasons? unknown.

Evaluation: Species Included: Sandhill crane (feeding/summer distribution, staging areas [none in study area] breeding areas, and sightings of pair or pairs with young on fringes of known breeding range from May to July) great blue heron, cattle egret, snowy egret (rookeries of these species) and sighting and rookeries of double crested cormorant, black-crowned night heron, gulls, white-faced ibis, long-billed curlews, Caspian tern, Forster's tern, and common egret (none of these species mapped in study area). Distribution from field studies. Years of Original Mapping: in progress. Years Updated: NA. Numbers of Years of Data: unknown.

Subjective Evaluation of Mapping System: Little usefulness to OIA study because most species and most mapping efforts are outside of the study area.

Comment: Overlays on BLM map showing land ownerships.

Utah Division of Wildlife Resources. in preparation. Threatened, endangered and sensitive species maps. Unpublished maps, prepared by UDWR Regional Offices (Ogden, Utah). (MAPPING)

Location: UDWR Northern Regional Office, 513 East 5300 South, Ogden, Utah.

Contact Person: George Wilson, Cathy Denny

Type of Map: Species Distribution, (overlay).

Area Covered: Rich and Cache Counties (1 map), Summit County (1 map), others covering remainder of Northern Region.

Scale: 1" = 10560' or 1/2" = 1 mile.

Evaluation (Habitat Maps): Resolution: Bald eagle winter concentration areas - 30 acres. Grounds Truthed? Yes.
Number of Seasons: unknown.

Evaluation (Species Occurrence Maps): Species Included: Bald eagle (winter concentration areas. roosts) Utah cutthroat trout (important streams). Distribution from field studies. Year of Original Mapping: in progress. Years Updated: NA Number of Years of Data: unknown.

Subjective Evaluation of Mapping System: Very useful for identifying critical and sensitive areas.

Comment: Overlays on BLM maps showing land ownership.

Utah Division of Wildlife Resources. in preparation. Upland game No. 1 maps. Unpublished maps, prepared by UDWR Regional Offices (Ogden, Utah). (MAPPING)

Location: UDWR Northern Regional Office, 513 East 5300 South, Ogden, Utah 84403.

Contact Person: George Wilson, Cathy Denny

Type of Map: Habitat, Species Distribution (overlay).

Area Covered: Rich and Cache Counties (1 map), Summit County (1 map), others covering remainder of Northern Region.

Scale: 1" = 10560' 1/2" = 1 mile.

Evaluation: Habitat Types Mapped: Sage grouse habitat (leks, winter range, breeding range), ruffed grouse, blue grouse (brooding and population range) snowshoe hare (population range). Resolution: Sage grouse: leks + 2 mile radius circle; winter range: 100-200 acres, breeding: 50 acres, others: 10,000 - 20,000 acres. Ground Truthed? Yes. Number of Seasons? unknown.

Evaluation Species Included: Sage grouse, ruffed grouse, blue grouse, snowshoe hare. Inferred distribution and distribution from field studies (see resolution and habitat mapped). Year of Original Mapping: in progress. Years Updated: NA.

Subjective Evaluation of Mapping System: Most useful for sage grouse, UDWR staff feel that inventory is fairly complete. Usefulness for other species limited by resolution.

Comment: Sage grouse mapping is best, supported by field work with little inference. Other species are based primarily on inference, supported by field observations. Overlays on BLM map showing land ownerships.

Utah Division of Wildlife Resources. in preparation. Upland game No. 2 maps. Unpublished maps, prepared by UDWR Regional Offices (Ogden, Utah). (MAPPING)

Location: UDWR Northern Regional Office, 513 East 5300 South, Ogden, Utah.

Contact Person: George Wilson, Cathy Denny

Type of Map: Species Distribution, (overlay).

Area Covered: Rich and Cache Counties (1 map), Summit County (1 map), others covering remainder of Northern Region.

Scale: 1" = 10560' 1/2" = 1 mile.

Evaluation: Resolution: California quail, chukar, and white-tailed ptarmigan 120-130 acres, Hungarian partridge 280-300 acres, ring-necked pheasant 500 acres. Ground Truthed? Unknown.

Evaluation (Species Occurrence Maps):

Species Included: California quail, chukar, ring-necked pheasants, Hungarian partridge, and white-tailed ptarmigan.

Distribution inferred and from field studies (see comments). Year

of Original Mapping: in progress. Years Updated. Number of

Years of Data: unknown.

Subjective Evaluation of Mapping System: Some value for identifying species present, but value is limited by resolution and basis of data. See comments.

Comment: Population distribution for all species are based on introduction reports, with some support from field observations. For white-tailed ptarmigan documented existing populations, undocumented populations, and potential habitat are differentiated. Overlays on BLM maps showing land ownership.

Utah Division of Wildlife Resources. n.d. Fisheries computer printout. Unpublished data. (RAW DATA)

Location: UDWR Northern Regional Office, 513 East 5300 South Ogden, Utah.

Contact Person: George, Cathy Denny.

Evaluation: Design: Streams are rated by class (includes aesthetics and other human values), productivity in 5 classes (1=worst, 5=best) list of 60+ species present, and fishery value class (I-IV and unsurveyed).

Value to OIA Study: Geographic Area Covered: Variable - depends on computer input. Baseline Data: Some parts may be repeatable, but resolution has been lost by placing data in classes. Further Study: Individual streams reach data should be entered as available. Potential for Use in Wildlife Management: Useful for fishery management.

Subjective Rating of Document: The printout is a useful document for fisheries management, its major value is putting all the streams in one data base.

Utah Division of Wildlife Resources. 1956. Thirty-second biennial report of the State Fish and Game Commission of the State of Utah. Prepared by UDWR Information and Education Division, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah or UDWR.

Evaluation: See UDWR (1964).

Utah Division of Wildlife Resources. 1958. The State of Utah Department of Fish and Game Thirty-third biennial report. Prepared by UDWR Information and Education Division, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah or UDWR.

Evaluation: See UDWR (1964).

Utah Division of Wildlife Resources. 1960. The State of Utah Department of Fish and Game 34th biennial report. Prepared by UDWR Information and Education Division, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah or UDWR.

Evaluation: See UDWR (1964).

Utah Division of Wildlife Resources. 1964. Big game harvest report, 1963. UDWR Departmental Information Bulletin 64-1, Project W-65-R-12, dated 15 Mar 64, Salt Lake City, Utah (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: See Stapley (1970)

Utah Division of Wildlife Resources. 1964. 36th Biennial Report Utah State Department of Fish and Game. Prepared for publication by Information and Education Division, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah or UDWR.

Evaluation: Design: Provides general overview of all Department activities from 1 July 1962 to 30 June 1964. Timing: 2 years. Analysis Methods: Presents totals and percentages, mostly qualitative.

Subjective Rating of Document: Provides an overview of department activities and state-wide and local statistics of general interest.

Utah division of Wildlife Resources. 1966. Utah big game harvest 1965. UDWR Publication 66-1, Project W-65-R-14, dated 15 Mar 1966, Salt Lake City, Utah (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: See Stapley (1970)

Utah Division of Wildlife Resources. 1966. Utah upland game bird harvest 1965. UDWR Publication 66-5, Project W-65-R-14, dated 1 June 1966, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: A questionnaire was sent to a 10% sample of hunters asking for number of each species killed, county hunted, and number of days hunted. Includes data on pheasant, chukar, dove, sage grouse, forest grouse, quail, Hungarian partridge, and wild turkey. Data for chuckar is presented by county because of a special season (no success in study area). Timing: 1 season. Analysis Meth-

ods: Total harvests were extrapolated and percentages and averages calculated. Hunter numbers, birds/hunter, birds/hunter day, and total harvests are each compared with 1964 and 7-year averages.

Value to OIA Study: Conclusions: Rich and Summit Counties were apparently closed for sage grouse. Neither was a particularly high producer of any other species. Baseline Data: Could be used to calculate long term trends. Further Study: None recommended.

Subjective Rating of Document: Provides good quality data on upland game birds on a county-wide scale.

Utah Division of Wildlife Resources. 1966. 37th Biennial report, Utah State Department of Fish and Game. Prepared by UDWR Information and Education Division, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah or UDWR.

Evaluation: Design: See UDWR (1964).

Utah Division of wildlife Resources. 1967. Utah big game harvest 1966. UDWR Publication 67-2, Project W-65-R-15, dated 15 Mar 1967. Salt Lake City, Utah (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: See Stapley (1970)

Utah Division of Wildlife Resources. 1968. Utah big game harvest 1967. UDWR Publication 68-1, Project W-65-R-16, dated 15 Mar 1968, Salt Lake City, Utah (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: See Stapley (1970)

Utah Division of Wildlife Resources. 1969. Utah big game harvest 1968. UDWR Publication 69-3, Project W-65-R-17, dated 15 Mar 1969, Salt Lake City, Utah (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: See Stapley (1970)

Utah Division of Wildlife Resources. 1971. Utah big game investigations and management recommendations 1970-1971. UDWR Publication 71-6, Project W-65-R-19, dated 1 July 1971, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Deer: includes land ownership patterns, 10-year summary of harvest and pressure, 9-year summary of county of residence of hunters, browse utilization and leader length for 5 years, 5-year pellet group transect trends, herd composition (buck, doe, fawn, and fawns/100 does) for pre- and post-season for 5 years, age and classification of harvest for 5 years, a narrative description of range and

herd condition, and season recommendations by herd unit.

Elk: land ownership patterns, harvest and pressure summary for 6 years, known illegal kill summary for 7 years, composition (bull, cow, calves, unclassified) for 5 years and same for pre-season for 3 years (no post-season), age of harvest bulls from questionnaires and field checks, pellet group trends, and narrative description of herd and range condition. (First helicopter census this year). All by herd area. Antelope: No data for study area, but each unit includes land ownership, introduction and transplant data, 10 year harvest (buck/doe) and pressure summary, undefined trend counts, 4-year classification counts (buck, doe, fawn, doe:fawn ratio), agreed maximum numbers, and harvest recommendations. Moose: Land ownership, 5-year harvest and pressure summary, composition for 5 years (bulls, cows, calves, unclassified). Two units are in the study area. Also includes bison and desert bighorn. Timing: Variable, see design. Analysis Methods: Totals, averages, percentages, and extrapolated data are presented.

Value to OIA Study: Conclusions: Conclusions are specific to herd units and are valuable to OIA. Baseline Data: Could be used to calculate long term trends.

Subjective Rating of Document: Provides a considerable amount of valuable data.

Utah Division of Wildlife Resources. 1972. Utah big game investigations and management recommendations 1971-1972. UDWR. Publication No. 72-6, dated July 1972, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: See UDWR (1971).

Utah Division of Wildlife Resources. 1973. Utah big game harvest 1972. UDWR Publication 73-3, Project W-65-R-D-21, dated 8 May 1973, Salt Lake City, Utah (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: See Stapley (1970).

Utah Division of Wildlife Resources. 1974. Utah big game harvest 1973. UDWR Publication 74-4, Project W-65-R-D-22, dated 1 May 1974, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: See Stapley (1970).

Utah Division of Wildlife Resources. 1974. Utah big game investigations and management recommendations 1973-1974. UDWR Publication 74-5, Project W-65-R-D-22, dated 14 June 1974, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: See UDWR (1971).

Utah Division of Wildlife Resources. 1975. Utah big game harvest report 1974. UDWR Publication 75-2, Project W-65-R-D-23, dated 31 Mar 1975, Salt Lake City, Utah, (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: See Stapley (1970).

Utah Division of Wildlife Resources. 1976. Big game harvest report 1975. UDWR Publication 76-6, Project W-65-R-D-24, dated 15 April 1976, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: See Stapley (1970).

Utah Division of Wildlife Resources. 1977. Big game harvest 1976. UDWR Publication 77-4, Project W-65-R-D-25, dated 20 April 1977, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: See Stapley (1970).

Utah Division of Wildlife Resources. 1977. Central Utah Project, Bonneville Unit, Jordanelle-Provo River system, biological inventory final report wildlife. Unpublished, prepared by UDWR, Salt Lake City, Utah. (ANALYZED DATA)

Location: U.S. Bureau of Reclamation, Provo, Utah.

Evaluation: Design: Big game by aerial census, browse transects, pellet group transects, and sex and age transects. Small mammals were trapped. Birds were studied by methods outlined in Emlen (1971), Gates, Marshall and Olsen (1968), Breckenridge (1935), and Craighead and Craighead (1935, 1956, and 1968). Timing: 14 months. Analysis Methods: Percentages, averages densities, and "ERA" were calculated.

Value to OIA Study: Conclusions: Discusses impacts that would result from project construction on a variety of species. Baseline Data: Good quality baseline data for this area. Further Study: None recommended.

Subjective Rating of Document: This is a good quality inventory of wildlife resources in the area studied.

Utah Division of Water Resources. 1977. Environmental conditions inventory. Unpublished draft report, dated March 1977, prepared for SCS, USFS, USDA Economic Research Service, and the states of Idaho, Utah, and Wyoming. (ANALYZED DATA)

Location: U.S. Soil Conservation Service, Salt Lake City.

Evaluation: Design: Ratings of "environmental resources" regarding human interest, biotic, and land and air quality in the Bear River Basin. Timing: Unknown. Analysis Methods: Rating factors

were set up for some factors, but the discussion of wildlife is qualitative.

Value to OIA Study: Conditions: Tabulations of characteristics (range condition, stream aesthetics, etc.) by subdrainage are the only useful conclusions. Baseline Data: Limited value due to qualitative nature of some items and fairly large scale of the project. Further Study: May be useful as a framework for future planning studies. Subjective Rating of Document: The main value of this document is the brief discussion of historical wildlife resources and the statistics presented.

Utah Division of Wildlife Resources. 1977. Utah big game investigations and management recommendations 1976-1977. UDWR Publication 77-5, Project W-65-R-D-25, Job A-2, dated 15 June 1977, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: See UDWR (1971).

Utah Division of Wildlife Resources. 1978. Big game harvest report 1977. UDWR Publication 78-2, Project W-65-R-D-26, dated 20 April 1978, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: See Stapley (1970).

Utah Division of Wildlife Resources. 1979. Big game harvest report 1978. UDWR Publication 79-5, Project W-65-R-D-26, dated April 1979, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: See Stapley (1970).

Utah Division of Wildlife Resources. 1979, 1980. Notification of intent to apply for Federal Aid. Unpublished application forms prepared by UDWR, Salt Lake City, Utah. (RAW DATA)

Location: Bear River Association of Governments, 170 North Main, Logan Utah

Contact Person: Marie Woodard.

Value to OIA Study: Geographic Area Covered: All of Utah. Baseline Data: Not repeatable. Further Study: None recommended. Potential for Use in Wildlife Management: Includes applications for aid to Commercial Fisheries R&D "Potential of the Utah Chub to support a bait fish industry in Utah" and "Physiological and genetic studies of trout strains in commercial and agency hatcheries", Statewide Endangered Species Program, Fish Restoration and Wildlife Restoration.

Utah Division of Wildlife Resources. 1980. Big game harvest report 1979. UDWR Publication 80-5, Project W-65-R-D-28, dated 20 April 1980, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: See Stapley (1970).

Utah Division of Wildlife Resources. 1980. Utah big game investigations and management recommendations 1979-1980. UDWR Publication 80-6, Project W-65-R-D-28, Job A-2, dated 29 May 1980, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: See UDWR (1971).

Utah Division of Wildlife Resources. 1981. The 1980 Utah big game harvest book. UDWR Publication 81-3, Project W-65-R-D-29, dated 1 April 1981, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: See Stapley (1970).

Vaughn Hansen Associates. 1979. Mahogany Hills natural resource inventory and master plan, a recreational development at Bear Lake for Arnold Development Company. Unpublished, prepared to meet requirements of Bear Lake Commission, dated February 1979. (ANALYZED DATA)

Location: Bear Lake Regional Commission, Fish Haven, Idaho.

Evaluation: Design: Qualitative discussion of small game and big game, including species list. Timing: 1 field reconnaissance.

Analysis Methods: Qualitative.

Value to OIA Study: Conclusions: Includes general recommendations for big game, domestic pets, snowmobiling, etc. Baseline Data: too qualitative to be of value.

Subjective Rating of Document: The value of this document is limited by its qualitative nature.

Type of Map: Habitat. Area Covered: Parts of Sections 7, 18, and 17 near Bear Lake State Park. Scale: 1:1200.

Evaluation: Habitat Types Mapped: Minimal impact (highly tolerant summer and winter range), feeding corridors, winter range (sensitive) possible revegetation areas (highly tolerant), travel corridors. Resolution: 1/2 acre. Ground Truthed? Yes. Number of Seasons: One.

Villatek. 1976. Swan Creek Village reconnaissance, Bear Lake, Utah. Unpublished, prepared to meet the requirements of Bear Lake Regional Commission. (ANALYZED DATA)

Evaluation: Design: Based on field reconnaissance and literature review, contains discussions of mammals, birds, including habitat,

qualitative abundance four seasonal status. Timing: One field reconnaissance. Analysis Methods: qualitative.

Value to OIA Study: Conclusions: Very briefly identifies impacts, concludes that opportunity exists to improve winter range. Baseline Data: No value - too qualitative.

Subjective Rating of Document: The value of this document is limited by its qualitative nature.

Other Comments: Wildlife section by Applied Ecosystems, Salt Lake City, Utah.

Type of Map: Habitat. Area Covered: Swan Creek development area near Garden City, Utah. Scale: 1:3600.

Evaluation: Habitat Types Mapped: Migration routes, big game habitat, grouse habitat, and green belt. Resolution: 1/2 acre. Ground Truthed? Yes. Number of Seasons: One.

Wagner, P. 1981. Midwinter Bald Eagle count results. Unpublished, letter to Bob Benton, dated 27 February 1981. (RAW DATA)

Location: U.S. Fish and Wildlife Service, Salt Lake City.

Contact Person: Bob Benton

Evaluation: Design: Standard midwinter Bald Eagle count methods - observers stationed at points or assigned routes to count eagles. Timing: 4 weeks over 2 years.

Value to OIA Study: Geographic Area Covered: Northern Utah, including Rich and Summit Counties. Baseline Data: Repeatable. Further Study: Midwinter Bald Eagle count is ongoing. Potential for Use in Wildlife Management: Useful because sensitive areas are identified, letter contains summary data by county (location and population estimates).

Subjective Rating of Document: Potentially useful, although observers - report sheets should be used for analysis.

Wagner, P. 1982. Midwinter Bald Eagle Count results. Unpublished. Letter to Bob Benton, dated 16 March 1981. (RAW DATA)

Location: U.S. Fish and Wildlife Service, Salt Lake City.

Contact Person: Bob Benton

Evaluation: Design: Standard Midwinter Bald Eagle Count methods - observers stationed at points or assigned routes to count eagles. Timing: 6 weeks over 2 years. Anticipated Completion Date: Ongoing.

Value to OIA Study: Geographic Area Covered: Northern Utah, including Rich and Summit Counties. Baseline Data: Repeatable. Further Study: Ongoing study. Potential for Use in Wildlife Management: Useful because sensitive areas are identified, letter contains summary data by county (locations and population estimates).

Subjective Rating of Document: Potentially useful, although observers' data sheets should be used for any analysis.

Walter, R.E. (ed.) 1981. Utah bird latilong distribution. Unpublished report prepared by non-game section, UDWR, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR.

Evaluation: Design: Includes a matrix of status, habitat, and abundance (many sub-categories) and requests reports of sightings in degree blocks. Analysis Methods: Literature review.

Value to OIA Study: Conclusions: Conclusion is in matrix form. Baseline Data: No value. Further Study: none recommended.

Subjective Rating of Document: The matrix has some predictive value for bird studies, and may be useful if non-game birds were used as ecological indicators.

Weber, D.A. 1975. Blue grouse ecology, habitat requirements, and response to habitat manipulation in north-central Utah. Special Report No. 33 Utah Cooperative Wildlife Research Unit. Prepared for USFS, UDWR, and USU, dated 1 May 1975. (ANALYZED DATA)

Location: Wasatch-Cache NF Supervisor's Office, 125 South State St., Salt Lake City, Utah.

Evaluation: Design: Male territories were located by flushing or calling, nests and broods were located, migration timing was determined by observation, vegetation was analyzed by Daubenmire's method, and abundance was analyzed and compared with juvenile crop contents. Timing: 4 years. Analysis Methods: Percentages and averages were calculated.

Value to OIA Study: Conclusions: Found that woody cover and sagebrush near meadows were valuable habitat; and recommends no herbicide spraying near these areas. Baseline Data: Little or no value, outside study area.

Subjective Rating of Document: This document focuses on the effects of an herbicide project, but provides some useful information.

Wennergren, E.B., H.H. Fullerton, and J.C. Wrigley. 1973. Estimation of quality and location values for resident deer hunting in Utah. Bulletin 488, Utah Agriculture Experiment Station, dated August 1973, Logan, Utah. (ANALYZED DATA)

Location: Utah Agricultural Experiment Station, Logan, Utah.

Evaluation: Design: Economic values of hunting in Utah deer herd units was calculated. Data was obtained from UDWR harvest reports and a mailed questionnaire. Timing: 1 season, compared with 2 other

seasons and an 8 year average. Analysis Methods: Stepwise multiple regressions, percents, and averages were calculated.
 Value to OIA Study: Conclusions: Herd units in the study area ranked on a state-wide basis: Lost Creek -third, Coalville - seventh, Kamas - 17th, others lower. Ratios of areas of summer range to winter range and number of deer killed per trip were the most important variables. Baseline Data: Warranted only if there is a need to calculate value of deer hunting or deer killed in the study area.
 Subjective Rating of Document: The major value of this document is to give a state-wide perspective to the value of deer hunting in the study area.

White, D.A. 1972. Part 4 ichthyofanna of proposed dam and reservoir sites of the Bonneville Unit of the Central Utah Project. Unpublished, prepared by Center for Health and Environmental Studies and Department of Zoology, Brigham Young University, dated July 1972. (RAW DATA)

Location: U.S. Bureau of Reclamation, Provo, Utah.

Contact Person: Bob Christensen

Evaluation: Design: Compilation of data from literature, including native/introduced/stocked status, food web positions, abundance (from UDWR), and anticipated effects of project in fishes at Jordanelle and other reservoir sites. Timing: 6 weeks.

Value to OIA Study: Geographic Area Covered: Jordanelle Reservoir site is in Summit County, other sites outside study area. Baseline Data: Not repeatable - literature compilation. Potential for Use in Wildlife Management: Useful in site specific areas.

Subjective Rating of Document: Limited value, useful on specific sites.

White, R.G. 1974. Endemic whitefishes of Bear Lake, Utah Idaho: a problem in systematics. Dissertation. Utah State University, Logan, Utah. (ANALYZED DATA)

Location: Utah State University Library, Logan, Utah.

Evaluation: Design: Collections of whitefish were made in Bear Lake using an 8.2 m semi-balloon, otter trawl, or horizontal sinking multi- and monofilament nylon gillnets for a study of systematics. Sex, state of maturation, length, weight, date, time, location, depth and method of capture data recorded. Morphological and electrophoretic analysis. Hybridization studies. Timing: June 1969 - December 1972. Analysis Methods: Multiple discriminant function analysis for comparisons with morphological differentiations.

Value to OIA Study: Conclusions: Morphological, ecological, and hybridization analyses provided evidence for separate recognition of 2 forms of Bonneville whitefish. Baseline Data: Baseline data on distribution of whitefish in Bear Lake.

Subjective Rating of Document: Has little value for OIA study - a systematics study only.

Williamson, J.H. 1970. Stomach Capacity, Digestion Rate and 24-hour consumption rate for the Bear Lake sculpin (Cottus Extensus). Thesis. Utah State University, Logan, Utah. (ANALYZED DATA)

Location: Utah State University Library (special collections), Logan, Utah.

Evaluation: Design: Determine rate of consumption and digestion, based on fish size, and seasonal environmental parameters. Bear Lake sculpin were captured using bottom trawl. Fish were kept live for digestion studies, or killed for stomach volume studies (n=157).

Timing: 1970. Analysis Methods: Data tabulated (means, variances, confidence intervals). Curvilinear regression.

Value to OIA Study: Conclusions: Information on energy transfers through the aquatic food web were determined. Seasonal and environmental factors were significant. Baseline Data: Not suitable.

Further Study: Information could be used for computer simulation model of Bear Lake system.

Subjective Rating of Document: Limited value for management of Bear Lake.

Wilson, D.E. 1971. Carrying capacity of the key browse species for moose on the north slope of the Uinta Mountains, Utah. UDWR Publication 71-9, Project W-65-RD-19, dated August 1979. (Also: Thesis. Utah State University, Logan, Utah). (ANALYZED DATA)

Evaluation: Design: Caloric requirements of moose were determined by body size and available forage was determined by dot grid and wandering quarter method sampling. Timing: 2 years. Analysis Methods: Percentages, averages, and standard error was calculated. Data indicates 90% confidence.

Value to OIA Study: Conclusions: Carrying capacity was estimated at 80,030 moose days on winter range or 450 adults (115 bulls, 250 cows, and 156 calves) for six months. Baseline Data: Could be useful baseline data. Further Study: Follow-up would be indicated if moose management problems are evident.

Subjective Rating of Document: Provides good data on moose carrying capacity, useful for both planning and impact assessment.

Winget, R.N. et al. 1975. Environmental studies of proposed Jordanelle Reservoir site, Provo River, Utah Lake, Jordan River, proposed Lampton Reservoir site. Unpublished, prepared by Center for Health and Environmental Studies, Brigham Young University, dated 1 April 1975. (RAW DATA)

Contact Person: Bob Christensen

Evaluation: Design: Qualitative summary of 1972 data, supplemented by UDWR data and brief review of additional literature.

Value of OIA Study: Geographic Area Covered: See title. Potential for Use in Wildlife Management: Limited usefulness.

Subjective Rating of Document: Value is limited by the qualitative nature of the document.

Winn, D.S. 1976. Terrestrial vertebrate fauna and selected coniferous forest habitat types on the north slope of the Uinta Mountains. Unpublished report dated 22 December 1976. Prepared for the Wasatch-Cache National Forest, Salt Lake City, Utah.

Location: Wasatch-Cache NF Supervisor's Office, Salt Lake City, Utah.

Evaluation: Design: Species occurrence in 5 habitat types and 4 subtypes was determined through trapping, pellet counts, track counts, scout poats, and bird censuses. Habitats included aspen and lodgepole - aspen, lodgepole pine, lodgepole - Vaccinium scoparum, two subtypes of lodgepole - Calamagrostis canadensis, and Engleman fir - lodgepole - vaccinium. Timing: 3 years. Analysis Methods: Used similarity indices, diversity indices, various significance tests, and regression analysis.

Value to OIA Study: Conclusions: Includes conclusions about habitat preferences, opening values, and understory and downed woody material, and rotation age regarding wildlife. Also makes recommendations for timber harvests. Baseline Data: May be useable. Further Study: See Dave Winn in USFS RO.

Subjective Rating of Document: High quality research data on wildlife/habitat relationships, but limited to a few habitat types.

Comment: See Winn's dissertation (Winn 1976).

Winn, D.S. 1976. Relationships between terrestrial vertebrate fauna and selected coniferous forest habitat types on the north slope of the Uinta Mountains. Dissertation. Utah State University, Logan Utah. (ANALYZED DATA)

Location: Fisheries and Wildlife Department (F&W Coop Unit Section), Utah State University, Logan, UT

Evaluation: Design: Objectives: 1) relate wildlife responses to lodgepole pine management practices in a "barometer" watershed in Summit County, 2) correlate wildlife densities with community structure, and 3) propose a management plan to manipulate wildlife densities. Tree stand and topographic data were recorded at each stand. 12 plots were sampled each year. Birds were censused for 3 hours at each site. Small mammals were trapped twice (6 nights) at each site. Densities were estimated with capture-recapture and Schnabel estimators, home areas from possibility ellipses. Pellet

groups and squirrel middens were censused. Detailed vegetation plots (.09 acre) were done. Big game track counts, and scent posts for coyotes & bobcats were used. Timing: 1972 - 1975. Analysis Methods: Means, ranges, confidence intervals, least significant difference test, density estimators, coefficients of similarity, regression analysis, cluster analysis, plant and animal diversity, and Kruskal - Wallis test.

Value to OIA Study: Conclusions: Lodgepole pine comprises major areas of the Uinta north slope, and large clearcuts are proposed. 53 lodgepole stands were sampled, defining 8 community types. A summary is given for tree populations, coverage, and frequency of undergrowth species. Response of wildlife densities to forest communities, forest structure, utilization of ecotones, and clearcut sizes. Wildlife species were found to exhibit preferences for specific types. Bird species are closely associated with understory biomass and diversity. Downed woody material enhances big game calving and resting areas. Density estimates for 16 mammal species are given, importance values for 37 bird species, by community types. Baseline Data: Valuable baseline data on mammal, bird populations in lodgepole pine forests. Further Study: Long-term objectives for timber sales should be developed to insure variety of communities of wildlife species within an area. Irregular edges and buffers, moist site, and climax stages should be included.

Subjective Rating of Document: Valuable information on habitat associations of big game and non-game birds and mammals in lodgepole pine forest on Uinta Mountains should be considered in assessing oil and gas impacts.

Workman, G.W. 1963. An ecological study of the Bear Lake littoral zone, Utah-Idaho. Dissertation. Utah State University, Logan, Utah. (ANALYZED DATA)

Location: Fisheries and Wildlife Department, Utah State University, Logan, UT.

Evaluation: Design: Six stations were established around Bear Lake. Five physical and chemical parameters were sampled monthly from the littoral zone (shallow water). Plankton were collected from water samples. Near-shore fish were sampled with rotenone. Fish were also captured with gillnets and observed with scuba gear. Minnow traps were used at varying depths, over sand and rock bottoms, and near artificial rock piles. Timing: Sept. 1960 - Jan. 1962 Analysis Methods: Data presented graphically. Analysis of variance, partial correlation coefficients.

Value to OIA Study: Conclusions: Water chemistry parameters are presented for Bear Lake. Checklists of zooplankton and phytoplankton

found by Workman and other investigators are given. Bottom type and cover were important in determining fish densities. Sculpin and speckled dace were most common. Of 6 fish species, only sculpin occurred away from rocky areas. Dace increased near artificial rock clusters. Baseline Data: Water chemistry results are valuable baseline data for Bear Lake. Further Study: Further Study of ecological relationships of Bear Lake system should be made. Subjective Rating of Document: Valuable information on aquatic ecology of Bear Lake.

Zwank, P.J. 1979. Reduced recruitment in Utah mule deer relative to winter condition. UDWR Publication 79-11, Project W-65-R-D-25, Job B-7, dated 25 May, 1979. Salt Lake City, Utah. (Also: Dissertation. Utah State University, Logan, Utah.) (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: Design: Occurrences of corpora lutea and fetuses were recorded on 125 carcasses and 136 laparotomized deer, radio telemetry and captive monitoring was used to determine live birth rates and fawn survival. Nutritional status was calculated based on size, age, and fat in kidneys and femur marrow. Analysis Methods: Nutritional indices were calculated and significance was determined.

Value to OIA Study: Conclusions: A correlation was found between winter condition of does and reproductive success, but weights and sizes of fawns was not significant relative to fawn mortality. Baseline Data: Little intrinsic value, but a method for quantifying nutritional status is suggested. Further Study: May warrant further study in the OIA study area if operations have impacts on winter range.

Subjective Rating of Document: This study would be useful if intensive study of a deer herd in the study area is called for, otherwise its main value is to confirm expected correlations.

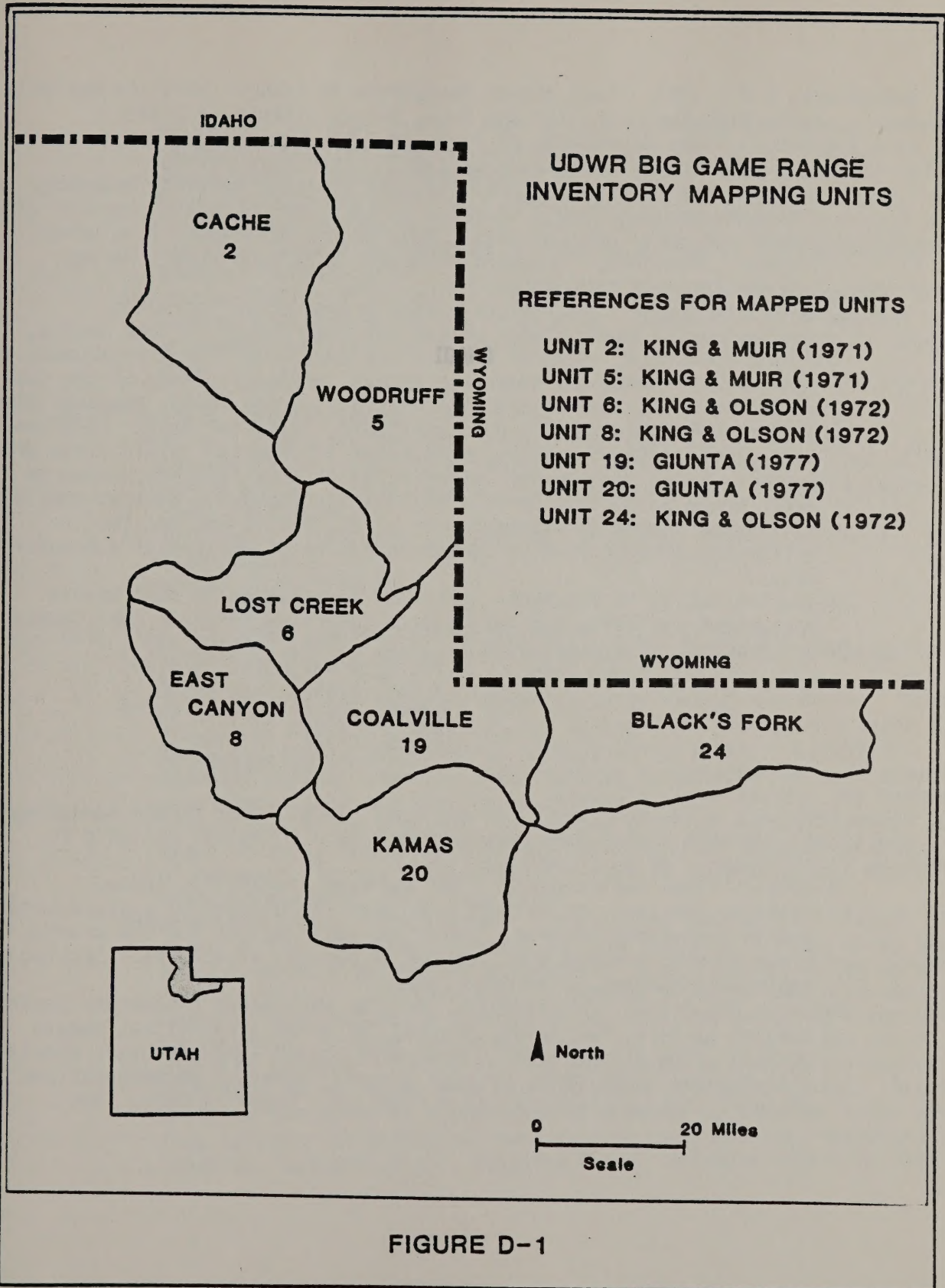


FIGURE D-1

Autenrieth, R.E. 1981. Sage grouse management in Idaho. Wildlife Bulletin No. 9. Idaho Department of Fish and Game, Boise. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Design: Summary of Idaho work to date. Literature review.

Radio-telemetry studies. Descriptions of leks, nesting, brooding, and wintering areas. Counts of males on leks, brood counts, harvest data. Effects of other habitat uses. Sage grouse Management Plan given.

Timing: 1946-1980. Analysis Methods: Data tabulated. Harvest information with sex ratios.

Value to OIA Study: Conclusions: Sage grouse occur in relict populations on small blocks of habitat (Bear Lake, Caribou County, Oneida counties). Adverse effects are resulting from encroachment of agricultural lands and sagebrush removal projects. Many of the leks, wintering areas, are on the high plateaus on the Idaho, Wyoming, Utah borders. Little specific data available. Baseline Data: Location of leks, other data will serve as baseline information on OIA study area. Further Study: recommends intensive efforts to identify, preserve leks, brood production areas. Methods for improving habitat should be considered (water development, etc.), as well as methods for mitigating effects of development (creation of artificial surrogate leks).

Subjective Rating of Document: detailed description of sage grouse management in Idaho, but only general overview for Bear Lake County.

Other Comments: Bear Lake County T 12S, R 46E, Section 23

Known Leks - T 13S, R 43E, Section 8, 29
T 14S, R 45E, Section 28
T 15S, R 43E, Section 15
T 15S, R 45E, Section 11
T 16S, R 45E, Section 21

Autenrieth, R., W. Molini, and C. Braun, eds. 1982. Sage grouse management practices. Western states sage grouse committee. Technical bulletin #1. Twin Falls, Idaho. 42 pp. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Guidelines presented for biologically-sound sage grouse management program. Describes best methods for lek counts, brood counts, harvest data, design of harvest strategies. Section on habitat management. Timing: 1982.

Value to OIA Study: Conclusions: Habitat management (sagebrush control) whether by fire, herbicide, grazing, or other alternative, should consider sage grouse needs. Post-development land-use goals should also include commitments to sage grouse. Numerous recommendations given for habitat protection, mitigation. Baseline Data: Not

suitable. Further Study: Sage grouse habitats, key areas, movement patterns, baseline habitat-vegetative data should be inventoried pre-development. Populations should be censused. Critical areas should be protected, and preferably remain undisturbed. Human access, activities, free-ranging dogs, etc. should be controlled on critical areas. Key areas should be enhanced or impacts mitigated post-development. Numerous methods given.

Subjective Rating of Document: Valuable indication of management problems of sage grouse on OIA study area. Suggestions for habitat management, mitigation of industrial development relevant on study area.

Bear Lake NWR. Aerial Photos. (MAPPING).

Location: Bear Lake National Wildlife Refuge, USFWS, Montpelier, Idaho.

Contact Person: Gerald L. Deutscher (Refuge Manager). Type of Map: Aerial Photos. Area Covered: Bear Lake National Wildlife Refuge, (Bear Lake County).

Aerial Photos: 1:6,000, 1:12,000 and 1:24,000. Date: 10/25/79. Type: Black & White.

Comments: 3 full series.

Bear Lake NWR, 1981. Annual Narrative Report. (ANALYZED DATA).

Location: Bear Lake National Wildlife Refuge, U.S.F.W.S., Montpelier, Idaho.

Evaluation: Design: Summary description of refuge activities. Includes results of monthly ground counts, spring and fall aerial Canada goose surveys, notable sightings of "sensitive" wildlife, results of colonial breeder counts. Also includes information on environmental conditions (snow and ice, rain, reservoir water levels) and management activities (grain planting, prescribed burning, carp control). Census begun of small number of mule deer wintering on uplands, at East edge of refuge. Timing: 1981. Similar reports available back to 1974. Analysis Methods: Data tabulated.

Value to OIA Study: Conclusions: Production, use-days for Canada geese, ducks on Bear Lake NWR. Colony nesters censused include snowy egret, black-crowned night-heron, white-faced ibis, double-crested cormorant, Franklin's gull, California gull, Forster's tern. Six bald eagles censused near refuge in Mid-Winter Survey. One whooping crane using territory on private land 1 mi. north of airport, also one other migrated through. Typically 2000 geese nest on refuge, producing 3000-4000 young (ducks produced estimated 2900-4700 young). Geese would be sensitive to disturbance from March to November (pair-bonding, territorial formation, nesting brooding, molting, pre-migratory behavior, successively). Baseline Data: Valuable base line data

for OIA study area. Further Study: Data would be more valuable if additional funds were available for waterfowl nesting surveys.

Subjective Rating of Document: Qualitative summary of more detailed records of waterfowl, etc. on Bear Lake Refuge. More detailed information is available in unpublished records (cited elsewhere). Best information available for waterfowl/waterbirds.

Bear Lake NWR. File: Annual output report. (RAW DATA).

Location: Bear Lake National Wildlife Refuge, U.S.F.W.S., Montpelier, Idaho.

Contact Person: Gerald I. Deutscher (Refuge Manager).

Evaluation: Design: Annual waterfowl breeding population, production, based on near-fledged broodcounts. Rough estimates on 7 mammal species. Production estimated from nesting numbers, nesting success (literature values), brood size. Timing: 1972-1982 annual report.

Value to OIA Study: Geographic Area Covered: Bear Lake National Wildlife Refuge (Bear Lake County). Baseline Data: Data of some value, although should be considered rough estimates due to difficulty of assessing various figures. Further Study: Some value as baseline information. Potential for Use in Wildlife Management: Valuable indication of waterfowl production on refuge. Data should be considered in assessing impacts of wildlife in the vicinity.

Subjective Rating of Document: Data of some value in determining numbers, seasonality of waterfowl use on OIA study area. Numbers, timing should be similar throughout bottomlands of Bear Lake County. Area is important waterfowl production site.

Other Comments: 1982 Data:

Species	Breeding #	Production	1981-Mammal	Population Size
American coot	1320	2475	Mountain cottontail	180
Canada goose	1500	2200	Beaver	5
Mallard	890	1490	Muskrat	4000
Gadwall	400	670	Red fox	6
Pintail	430	720	Striped skunk	40
3 species teal	750	1255	Mule deer	200
Redhead	704	1325	Moose	2
3 other species				

Bear Lake NWR. File: fall aerial waterfowl census. (RAW DATA).
 Location: Bear Lake National Wildlife Refuge, U.S.F.W.S., Montpelier, Idaho.
 Contact Person: Gerald L. Deutscher (Refuge Manager).
 Evaluation: Design: Aerial survey of waterfowl (Canada geese, mallards, green-winged teal, gadwalls, and others). Transects flown 1/2 mile apart, with 2 observers. Timing: 1980-1982, twice during September-November.
 Value to OIA Study: Geographic Area Covered: Bear Lake Refuge and vicinity; Bear River north to Soda Springs; Bear River east to Thomas Fork; Thomas Fork River. Baseline Data: Data collected same way each year. Counts may be poor estimates for smaller waterfowl. Further Study: Valuable baseline data. Potential for Use in Wildlife Management: Valuable assessment of waterfowl numbers in area during fall.
 Subjective Rating of Document: Valuable information for assessing impacts of exploration of waterfowl resources in Bear Lake County. Data should be considered in assessing impacts of oil and gas exploration.
 Other Comments: October 1982. Results:

	Canada Geese	Mallard	Green- Winged Teal	Other Ducks	Coots
Bear Lake Refuge	515	1396	342	400	1052
Bear River No. to Soda Springs	202	531	3	---	3
Bear River Ea. to Thomas Fork	419	323	5	4	5
Thomas Fork River	9	635	15	15	115

Bear Lake NWR. File: Monthly Waterfowl Populations. (RAW DATA).
 Location: Bear Lake National Wildlife Refuge, U.S.F.W.S., Montpelier, Idaho.
 Contact Person: Gerald L. Deutscher (Refuge Manager).
 Evaluation: Design: Estimates of numbers of waterfowl on refuge (mean and maximum estimates for the month). Sixteen species, ducks, Canada geese, American coots. (4000-16000 ducks during summer months). Data based on all sightings by Refuge personnel. Timing: 1972-1982.
 Value to OIA Study: Geographic Area Covered: Bear Lake National Wildlife Refuge (Bear Lake County). Baseline Data: Because of difficulties censusing waterfowl on this area, counts may be best considered as annual, seasonal trends. Results probably represent underestimate of actual numbers. Further Study: Better census

techniques would be used for ducks if time and funds were available. Potential for Use in Wildlife Management: Provides valuable information on numbers, timing of waterfowl use of Bear Lake Refuge and adjacent areas are very important waterfowl production area. Results should be considered in assessing impacts of oil and gas exploration.

Subjective Rating of Document: Very important wildlife resource on OIA study area. Best information available on waterfowl and other waterbirds.

Bear Lake NWR. File: Nesting surveys. (RAW DATA).

Location: Bear Lake National Wildlife Refuge, U.S.F.W.S., Montpelier, Idaho.

Contact Person: Gerald L. Deutscher (Refuge Manager).

Evaluation: Design: Nesting surveys on series of foot transects. Representative areas of refuge covered (16 transects, a few more added each year). Number of nests observed increased by an expansion factor (3-5 depending on species) to account for nests not seen, area not transected. This factor has been calibrated for geese only, using simultaneous ground and aerial counts. Timing: 1979-1982, June.

Value to OIA Study: Geographic Area Covered: Bear Lake National Wildlife Refuge (Bear Lake County). Baseline Data: Transects repeated each year. Results are expected to be underestimates. Further Study: Additional transects should be added. Potential for Use in Wildlife Management: Provides valuable information on numbers, timing of waterfowl nesting on Bear Lake NWR. This is a very important waterfowl production area for Southeast Idaho. Numbers and timing of waterfowl production should be considered in oil and gas exploration impacts.

Subjective Rating of Document: Valuable information on timing, numbers of nesting waterfowl on OIA study area.

Bear Lake NWR. File: Quarterly output reports-marsh and waterbirds. (RAW DATA).

Location: Bear Lake National Wildlife Refuge. U.S.F.W.S., Montpelier, Idaho.

Contact Person: Gerald L. Deutscher (Refuge Manager).

Evaluation: Design: Estimated use-days, peak population, estimated number of young produced, for non-game waterbirds on refuge. Data based on ground counts, annual trends. Timing: 1972-1982, quarterly reports.

Value to OIA Study: Geographic Area Covered: Bear Lake National Wildlife Refuge (Bear Lake County). Baseline Data: Data gathered same way each year but changes in environmental conditions may affect repeatability. Results are probably an underestimate of actual

numbers. Potential for Use in Wildlife Management: Valuable information on non-game waterbirds. Could be used for assessing impacts of disturbances on bottomlands on OIA study area, and for setting critical areas, dates.

Subjective Rating of Document: Valuable baseline information on non-game waterbirds on OIA study area. Several species considered "sensitive". Because of extreme difficulties censusing secretive marshbirds, these estimates should perhaps be considered as seasonal, annual trend counts. Numbers should be similar throughout wet areas of Bear Lake County.

Comments: Species surveyed: western, eared, pied-billed grebes, double-crested cormorant, white pelican, American bittern, great blue heron, snowy egret, black-crowned night-heron, greater sandhill crane, Virginia and sora rails, white-faced ibis. (Fall totals 1700-3000). Least use occurs during winter when water is frozen.

Bear Lake NWR. File: Quarterly output report - raptors. (RAW DATA).

Location: Bear Lake National Wildlife Refuge, U.S.F.W.S., Montpelier, Idaho.

Contact Person: Gerald L. Deutscher (Refuge Manager).

Evaluation: Design: Estimated use-days, peak populations, number of young produced for 14 raptor species. Based on ground counts on Refuge. Timing: 1972-1982, quarterly reports.

Value to OIA Study: Geographic Area Covered: Bear Lake National Wildlife Refuge (Bear Lake County). Baseline Data: Valuable baseline data on raptors on OIA study area. Potential for Use in Wildlife Management: Numbers, timing of raptors present, nesting information should be used for assessing impacts of oil and gas exploration.

Subjective Rating of Document: Valuable baseline information on non-game (some sensitive or endangered) raptors on OIA study area. Numbers, timing would probably be similar throughout the bottomlands of Bear Lake County.

Comment: Species surveyed: Turkey vulture, marsh, red-tailed, rough-legged, Swainson's, ferruginous hawks, golden and bald eagles, American kestrel, peregrine (1980, 78), prairie falcons, short-eared, screech, great horned owls. Numbers typically 50-100.

Bear Lake NWR. File: Quarterly output reports--shorebirds, gulls, terns, etc. (RAW DATA).

Location: Bear Lake National Wildlife Refuge, U.S.F.W.S., Montpelier, Idaho.

Contact Person: Gerald L. Deutscher (Refuge Manager).

Aerial Photos: Scale: 1:12500. Date: 10/1/55, 10/15/79. Type: Black & white infrared.

Comment: Valuable for assessing differences (especially allation) in 23 years.

Evaluation: Design: Estimated use-days, peak populations, estimated number of young produced, for non-game shorebirds. Based on ground counts, annual trends. Timing: 1972-1982, quarterly reports.

Value to OIA Study: Geographic Area Covered: Bear Lake National Wildlife Refuge (Bear Lake County). Baseline Data: Data gathered same way each year, but changes in environmental conditions may affect repeatability. Results are probably an underestimate of actual numbers. Potential for Use in Wildlife Management: Valuable information on non-game shorebirds. Should be used for assessing impacts of disturbances on bottomlands, riparian areas, and for setting critical areas, dates.

Subjective Rating of Document: Valuable baseline information on non-game shorebirds on OIA study area. Numbers, timing should be similar throughout bottomlands of Bear Lake County.

Comments: Species surveyed: California and Franklin's gulls, Caspian, Forster's and black terns, Wilson's phalarope, American avocet, black-necked stilt, common snipe, long-billed dowitcher, lesser yellow-legs, willet, spotted sandpiper, long-billed curlew, killdeer, etc. Fall counts typically 2000-9000 birds. Winter counts are lowest due to migratory nature of many species, and frozen water on Refuge.

Bear Lake NWR. File: Spring aerial count of goose pairs. (RAW DATA).

Location: Bear Lake National Wildlife Refuge, U.S.F.W.S., Montpelier, Idaho.

Contact Person: Gerald L. Deutscher (Refuge Manager).

Evaluation: Design: Aerial survey of Canada geese, sandhill cranes (other waterbirds recorded incidentally). Transects flown (1/2 mi. apart) on Bear Lake NWR and vicinity, Bear River north and east of refuge, and on Thomas Fork, 2 observers. Timing: Early May, 1979-1982. Birds classified as known pairs, indicated pairs, single birds, non-breeding groups. Value to OIA Study: Geographic Area Covered: Bear Lake County, Bear River and Bottomlands. Baseline Data: Data collected in same way each year. Believed to census high proportion of geese, cranes. Potential for Use in Wildlife Management: Valuable data on nesting and territorial geese and cranes. Should be considered in any impacts to bottomlands.

Comments: 1982 Results:

	Canada Geese	Sandhill Cranes
Bear Lake Refuge and vicinity	700 pairs	36 birds (1 whooper)
Bear River, no. to Soda Springs	200	9
Bear River, ea. to Thomas Fork	150	8
Thomas fork River	90	12

Bear Lake NWR. File: Wildlife-colonial nesters. (RAW DATA).

Location: Bear Lake National Wildlife Refuge, U.S.F.W.S., Montpelier, Idaho.

Contact Person: Gerald L. Deutscher (Refuge Manager).

Evaluation: Design: Ground counts of nests in active colonies censused 1-2 times, May-June. Actual ground counts, or estimates if counts would disrupt "sensitive" species. Timing: 1979-1980, annual reports.

Value to OIA Study: Geographic Area Covered: Bear Lake National Wildlife Refuge (Bear Lake County). Some colonies (white-faced ibis, great blue heron) censused off of the Refuge. Baseline Data: Data collected in same way each year. Some species change colony location unpredictably from year to year. Potential for Use in Wildlife Management: Colonial nesters may suffer greatest impact from disturbances. Numbers, timing of nesters should be considered in assessing impacts of oil and gas exploration. Colony nesters are often considered as environmental barometers.

Subjective Rating of Document: Valuable record of colonial nesters on Bear Lake Refuge. Data should be used to assess impacts on refuge and in nearby Bear Lake County.

Comments: 7-11 colonies located each year (locations may vary).

Species surveyed: California and Franklin's gulls, Forster's and black terns, double-crested cormorants, white-faced ibis, snowy egret, black-crowned night heron, great blue heron, western grebe. Colony sizes in 1982 varied from 11 to 17000. Several species are considered "sensitive".

Bear Lake N.W.R. Uncontrolled aerial photo mosaic. 2 large scale aerial photomaps of Refuge. (MAPPING).

Location: Bear Lake National Wildlife Refuge, U.S.F.W.S., Montpelier, Idaho.

Contact Person: Gerald L. Deutscher (Refuge Manager). Type of Map: Aerial Photos. Area Covered: Bear Lake National Wildlife Refuge (Bear Lake County).

Aerial Photos: Scale: 1:12000. Date: 10/1/56, 10/15/79. Type: Black & white infrared.

Comment: Valuable for assessing differences (especially siltation) in 23 years.

Benson, P.C. 1976. Land use and raptors on the Caribou National Forest. Unpublished report, prepared for Caribou National Forest. 90 pp. (ANALYZED DATA).

Location: Soda Springs District Office, Caribou National Forest, U.S. Forest Service, Soda Springs, Idaho.

Evaluation: Design: Inventory of raptors present on forest lands, and their habitat requirements. Indicates land uses which increase/decrease habitat for raptors. Determine measures which can mitigate effects of habitat alterations. Literature review. Limited data presented on raptors seen on road surveys. Timing: 1976. Analysis Methods: Raptors seen/man-hour.

Value to OIA Study: Conclusions: Problems: Raptors demand various habitats; generalizations cannot be made. Raptors are difficult to study due to their secretive nature. Species vary in sensitivity to human activity. General seasonal, habitat considerations are given for 11 diurnal raptors. General surveys effects of 46 types of land uses (recreation, mining, timber, transportation) on raptor use given. Variety of potential effects of land-use alternatives discussed. Special consideration given to key wildlife areas, including two just to north of OIA study area. Recommendations given for limiting oil and gas exploration impacts on raptors--most have to do with effects of increased vehicle access, human activity. Baseline Data: Limited baseline data.

Subjective Rating of Document: Some value as indication of management concerns with raptors on Caribou N.F. Literature review on effects of land-uses on raptors other wildlife. Too qualitative for some uses.

Brazell, R. 1979. Wildlife habitat management plan. Soda Springs Ranger District, Caribou National Forest. 166 pp. (ANALYZED DATA).

Location: Soda Springs Ranger District Office, U.S. Forest Service, Soda Springs, Idaho.

Evaluation: Design: Plan written to provide clear policies and strategies to guide management of wildlife populations and habitat. Measurable goals and objectives given to monitor progress. Timing: written 1979. Analysis Methods: Descriptions of various habitat improvements given with cost estimates.

Value to OIA Study: Conclusions: Variety of habitat improvement practices described, recommendations given for reducing impact of mining, logging, grazing, road access. Examples of habitat improvement: aerial seeding and shrub planting on big game winter range, prescribed burning of decadent aspen stands and willows, nest site protection for bald eagles and prairie falcons, fencing of waterholes and stream to protect nesting waterfowl; protection of sensitive areas -- elk calving areas, upland grouse brood-rearing areas, sandhill and whooping crane feeding and loafing areas; powerlines designed to protect raptors from electrocution. Baseline Data: Wildlife data not suitable - Soda Springs District immediately north of Bear Lake County. Recommendations do apply, however. Further

Study: Recommendations given for further study on area. Examples -- Inventory and location of big game winter ranges, ascertainment of habitat use patterns for important species, stream surveys, habitat improvement programs, water quality monitoring, wildlife management plans.

Subjective Rating of Document: Valuable listing of possible strategies for reducing impacts of disturbances to wildlife. Should apply directly to OIA area.

Brazell, R.E. 1981. Habitat parameters and management recommendations for seven selected wildlife species on the Soda Springs Ranger District, Idaho. M.S. Thesis, Utah State University, Logan, Utah, 240 pp. (ANALYZED DATA).

Location: Soda Springs Ranger District, U.S. Forest Service. Eastern part of Caribou County and southern Bonneville County (600 sq. mi).

Evaluation: Design: Literature was reviewed and various habitat factors assessed. Management recommendations were made for mitigation of negative impacts from mining, logging, grazing and recreation. Mule deer, elk, moose, sage grouse, ruffed grouse, blue grouse, and coyotes were considered. Habitat parameters considered were cover - hiding, escape, thermal; use of topographic factors - slope, aspect, elevation; characteristics of habitat utilization - seasonal, breeding, differences between males and females. Food habitats of each species were outlined. Timing: 1979-1981. Analysis Methods: Literature review.

Value to OIA Study: Conclusions: Management recommendations were made for 7 species. Most involved preservation of critical habitat (big game winter and summer ranges; grouse breeding, nesting, and brooding areas). Specific impacts dealt with habitat destruction - vegetation removal; increased roads - access, erosion, sedimentation; increased human population - recreation, off-road vehicles, snowmobiles, illegal harvest. Baseline Date: Because of nearness to OIA area (immediately to north of Bear Lake County), general considerations should apply. Further Study: Critical areas should be located in Bear Lake County.

Subjective Rating of Document: Valuable summary of knowledge of important species. Criteria provided can be used to assess impacts of planned oil and gas explorations. Data, however, is too qualitative to provide exact predictions.

Bureau of Land Management. 1978. Bear Lake Planning Unit, Resource Analysis. (ANALYZED DATA).

Location: Soda Springs Resource Area. Headquarters, BLM, Soda Springs, Idaho.

Evaluation: Design: Analysis of resources on Bear Lake Planning Unit (Bear Lake and Franklin Counties). General description of available habitat types, habitat requirements of big game, upland game birds,

waterfowl, fish, furbearers, and endangered and sensitive species. Includes literature review, harvest and population values from Idaho Department of Fish and Game and U.S. Fish and Wildlife Service. Timing: 1978. Analysis Methods: Data tabulated.

Value to OIA Study: Conclusions: Best available information summarized for 3 big game species, 8 upland game birds, 9 furbearers, 23 waterfowl, game fish including 5 found only in Bear Lake. BLM sensitive species - 5 mammals, 8 birds, 1 fish. Fish surveys given, and acreages of various habitats on BLM land. Small-scale maps of various wildlife habitats given, presented in larger scale, on overlay maps. Information also included on recreation use, archaeological sites. Baseline Data: Will serve as baseline data. Best information is on overlay maps. Further Study: Numerous recommendations made as to possibilities of improving wildlife habitat.

Subjective Rating of Document: Valuable documentation of available knowledge on variety of game and non-game species on OIA study area.

Bureau of Land Management. Bear Lake Planning Unit Resource Analysis - Overlay Maps. (MAPPING).

Location: Soda Springs Resource Area Headquarters, BLM, Soda Springs, Idaho.

Contact Person: Geoff Hogander (Wildlife Biologist). Type of Map: Habitat. Overlay. Area Covered: Bear Lake and Franklin Counties (primarily BLM managed lands).

Evaluation: Habitat Types Mapped: Variety of species: map #3-3 mule deer, elk, moose-summer and crucial winter range, #4 waterfowl habitat - resting and wintering areas #5 - upland game habitat - sage and sharptail grouse (6 known + other potential) leks, crucial wintering areas; hungarian partridge, chukars, #6 forest grouse (ruffed and blue), #7 endangered, threatened, and sensitive species - broad areas, not necessarily presently occupied - Bear Lake Refuge, white-faced ibis, long-billed curlew, merlin, ferruginous hawk, peregrine falcon, bald eagle, osprey, gyrfalcon, trumpeter swan, Bear River - otter; forest areas - marten, Canada lynx, bobcat, #8 Fish habitat - fishery rating, fish species, #9 wildlife management areas, - 5 browse transects, emergency feeding areas, #4-1. Wildlife habitat management opportunities. Resolution: 1/2 - 1 mile diameter. Ground Truthed: Yes, based on variety of sightings over the years.

Subjective Evaluation of Mapping System: Most comprehensive wildlife map of area. Includes non-game species to greater extent than other maps.

Bureau of Land Management. Caribou-Bear Lake Management Framework Plan. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello.

Evaluation: Design: Recommendations for protecting fishery and wildlife values on area. Timing: 1979. Analysis Methods: None.

Value to OIA Study: Conclusions: Fishery resources are to be protected - stream crossings will be constructed with culverts or bridges, no drilling within 500' of riparian areas, or trout waters, no drilling fluids will escape into streams. Protect and maintain habitat for sensitive species, potentially on area white-faced ibis, long-billed curlew, trumpeter swans, merlin, gyrfalcon, lynx, bobcat. Protect and maintain habitat for sage and sharp-tailed grouse - no drilling or construction within 2 mile of strutting grounds March 15 - June 30. Maintain beaver habitat. Protect potential endangered species habitat - bald eagle, whooping crane, peregrine falcon (all observed on area 1977-1979). Maintain existing waterfowl habitat to support increased numbers of breeding and migrating birds. Protect big game winter range - no mineral exploration November 15 - May 1. Support IDFG goals for increased populations. Protect crucial habitat for, and inventory raptor populations. Baseline Data: Not suitable as baseline data. Further Study: Additional information is needed on these critical wildlife habitats.

Subjective Rating of Document: Valuable indication of BLM concerns on OIA study area.

Bureau of Land Management. File: Big game winter range inventory, Soda Springs Resource Area. (RAW DATA).

Location: Soda Springs Resource Area Headquarters, BLM, Soda Springs, Idaho.

Contact Person: Geoff Hogander (Wildlife Biologist).

Evaluation: Design: Winter range inventory. Recorded range type, big game and livestock use, general condition, other wildlife observed, especially raptors, and development potential. Timing: 1968 and again 1975 (same data recorded, most areas revisited).

Value to OIA Study: Geographic Area Covered: Bear Lake County: Fossil Canyon, Georgetown Canyon, Montpelier Canyon, Alton Area, Geneva Summit, Raymond, North and East Bear Lake. Pegram Creek. Baseline Data: Data collection was repeated once, using same data format. Potential for Use in Wildlife Management: Can be used to assess trends on big game winter range, assess possible impacts.

Subjective Rating of Document: Some value as baseline information. Presumed to have been basis for many wildlife maps of area.

Bureau of Land Management. Wildlife Observation Reports. (RAW DATA).

Location: Soda Springs Resource Area Headquarters, BLM, Soda Springs, Idaho.

Contact Person: Geoff Hogander (Wildlife Biologist)

Evaluation: Design: Reports of sightings (usually by staff) on file cards. Observations of many species in Bear Lake County, and elsewhere in Caribou and Franklin Counties. Timing: 1979-1982.

Anticipated Completion Date: Ongoing.

Value to OIA Study: Geographic Area Covered: Bear Lake, Caribou, Franklin Counties. Baseline Data: Not suitable. Potential for Use in Wildlife Management: Record of unusual sightings on OIA study area.

Subjective Rating of Document: Some value in assessing habitat of unusual, important, or non-game species.

Comments: Sightings on OIA study area include: mule deer, elk, moose, sage grouse leks (T 11S, R 43E; T 15S, 45E, S 36 old lek; T 15S, 45E, S 25 possible lek; winter area T 16S, 45E, S 49), blue grouse, hungarian partridge, chukar, bald and golden eagles, rough-legged and swainson's hawks, prairie falcon, pheasant, some passerine birds. Peregrine falcon, burrowing owls observed just to north of study area. Also observed on study area - herptiles, cottontails, weasels, raccoon.

Chase, J.H. 1979. Accipiter nest survey in the northern portion of the Aspen range, southeast Idaho. Unpublished report. Idaho Department of Fish and Game, Soda Springs, 12pp. (ANALYZED DATA).

Location: IDFG, Soda Springs, Idaho. Cooperative Wildlife phosphate study area (20 mi², Middle Sulphur, Wood Canyons - 5 miles east of Soda Springs, 3 miles north of Bear Lake County).

Evaluation: Design: Road, snowmobile, foot survey of accipiter nest sites. Baseline data collected for nest size, nest tree characteristics, vegetation type, elevation, aspect, nearness to water. Timing: 1978-1979. Analysis Methods: Data tabulated.

Value to OIA Study: Conclusions: 18 active and inactive nests found, .20 - .25 active nests/mile surveyed. Most nests observed were goshawks. Other activity by Cooper's hawk, sharp-shinned hawks.

Baseline Data: Because of nearness and similar vegetation types to Bear Lake County, can serve as baseline for accipiter densities.

Subjective Rating of Document: Intensive study of small area. Should be applicable to similar habitat in Bear Lake County.

Comment: Accipiters believed to be declining throughout the West.

Chase, J.H. 1979. Seasonal abundance and habitat utilization of eleven raptors in the Cooperative Wildlife-Phosphate study area. Unpublished report. Idaho Department of Fish and Game, Soda Springs. 22 pp. (ANALYZED DATA).

Location: IDFG, Soda Springs, Idaho. Cooperation Wildlife-Phosphate study area. Census route along Blackfoot River, 12 miles northeast of Soda Springs. 11 miles north of Bear Lake County.

Evaluation: Weekly 15-mile vehicle survey of raptors. Seasonal abundance and utilization of vegetation types. Timing: August 1978-June 1979. Analysis Methods: Data tabulated by species, month, vegetation type, number seen/census, #/hr.

Value to OIA Study: Conclusions: 11 raptor species observed. Highest densities from March to September, (10-12 birds/census in summer, 1/census in winter). Kestrel, red-tailed hawk most common in summer, only golden eagle common in winter. Seasonal abundance, vegetation type utilization. Baseline Data: Results believed typical of the more open habitats. Should serve as baseline for Bear Lake County due to similar habitats.

Subjective Rating of Document: Intensive survey of open habitat. Applicable to Bear Lake County.

Connelly, J.W. 1980. Ecology of sagegrouse on the INEL site. Pages 29-45 in R.E. Autenrieth, G.L. Copeland, J.W. Connelly, and T.D. Reynolds. Federal aid to wildlife restoration. Antelope - sagegrouse ecology. Job progress report. Project W-160-R-7. Idaho Department of Fish and Game, Boise, Idaho. 120 pp. (RAW DATA).

Location: Idaho Department of Fish and Game, Soda Springs, Idaho.

Contact Person: Lonn Kuck (Senior Wildlife Biologist).

Evaluation: Design: Comprehensive study of sagegrouse ecology. Objectives include determination of population size, habitat use, movement patterns. Radio-telemetry, banding with colored tags. Line transect census route, brood census. Aerial location of leks, lek census. Vegetation plots on key-use areas. Timing: 1978-1981. Anticipated Completion Date: 1981.

Value to OIA Study: Geographic Area Covered: Idaho National Engineering Laboratory (west of Idaho Falls 1000 mi²). Baseline Data: Good techniques, should be repeatable. High recovery rate of banded birds. Further Study: Results should be applied to Bear Lake County populations. Potential for Use in Wildlife Management: Valuable data for sagegrouse management. Movement patterns, vegetation characteristics of leks and key use areas should be similar, and applicable to Bear Lake County.

Subjective Rating of Document: Useful information with potential value for management of sagegrouse on OIA study area. Habitat types may be expected to be similar in Bear Lake County.

Creston Valley Wildlife Management Authority. 1974. Literature review: Habitat requirements for ground-nesting waterfowl and effect of grazing and other cover removal activities on nesting. Unpublished report. 36 pp.

(ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Literature review of effects of grazing, etc. on waterfowl production. Timing: 1974.

Value to OIA Study: Conclusions: Production habitat is very important to waterfowl resource. Habitat is shrinking rapidly due to drainage of wetlands, grazing. The value of attractive and secure upland nesting cover cannot be overstated. Most species of ducks nest on land. Nesting as well as loafing and feeding areas must be present. The greater the density of tall dense nesting cover (including the previous years growth), the more nesting pairs there can be. Grazing causes trampling, desertion of nests, increased predation, as well as causing reduced nesting numbers. Other effects of grazing are lowered soil and water condition, loss of food plants. Haying and other plant removal near shore causes similar impacts. Baseline Data: Not suitable - literature review of studies done elsewhere. Further Study: None recommended.

Subjective Rating of Document: Valuable discussion of management problems, and habitat requirements of nesting waterfowl. Possible indication of methods for mitigating impacts of oil and gas exploration on waterfowl (off-site compensation).

Erman, D.C. 1969. Ordination of benthic invertebrate communities in Bear Lake. Dissertation. Utah State University, Logan, Utah. (ANALYZED DATA).

Location: Utah State University Library, Logan, Utah.

Evaluation: Design: Ordination methods were used to examine environmental relationships and benthic invertebrate community structure in the Littoral Zone of Bear Lake. Timing: Summer and Fall 1967.

Analysis Methods: Means of O_2 consumption and benthic invertebrate body lengths, correlation coefficients between environmental factors, Orloci and Bray - Curtis ordination, relative important values, comparisons made using relative efficiencies and multiple correlations.

Value to OIA Study: Conclusions: Two ordination effects of different quantitative species data (importance value) were compared. A new importance value was developed based on O_2 consumption. Comparison of O_2 importance value with density $\times$ (Frequency)^{0.5} showed differences in relative importance of species. Ordinations showed significant relationships between ordination axes, chironomid species, and environmental factors. Areas near human development were more eutrophic than undisturbed areas. Baseline Data: Valuable for studies of Bear Lake, lists of invertebrate species and their O_2 consumption. Further Study: This paper's techniques could be used for background if studies of Bear Lake are undertaken.

Subjective Rating of Document: Limited management value for Bear Lake. Data on Human Development impacts on benthic invertebrate communities.

Evans, L. 1981. Alternative wildlife replacement plans in response to phosphate resource development in southeastern Idaho mining region, using the WILDMIS system. In-house status report. Idaho Department of Fish and Game, Soda Springs, Idaho. 11 pp. (ANALYZED DATA).

Location: IDFG, Soda Springs, Idaho. Cooperative Wildlife-phosphate study area. (950 mi² in eastern Caribou and northern Bear Lake County).

Evaluation: Design: PATREC (pattern recognition habitat evaluation computer model) was used to predict loss of habitat potential to support big game, due to mining disturbances between 1950-2010. MANALT (management alternatives computer program) is being developed to provide yield figures (increase or decrease) in potential to support big game, for a given management action. Will be used to propose cost-effective means of replacing habitat losses. (See Lisa Evans, M.S. Thesis. In prep. Colorado State University). Analysis Methods: Computer habitat evaluation models. Data on potential big game losses presented graphically.

Value to OIA Study: Conclusions: Extensive losses in habitat potential to support big game predicted over next 30 years at sites of phosphate mining disturbances. Effects on overall study area less severe. Baseline Data: Because of closeness (includes some northern Bear Lake County) to OIA study area, model results should be applicable. Further Study: Develop strategies to replace projected losses in habitat potential to support big game.

Subjective Rating of Document: Important approach for assessing effects of mining disturbances, and determining appropriate mitigation strategies.

Comment: It should be noted that due to aspen succession towards climax conifer forest habitat losses will occur even in the absence of mining disturbance. Extension of material described in Evans 1982.

Evans, L. 1982. Computer implementation. Pages 4-149 in L. Kuck, E.H. Merrill, G. Hompland, and L. Evans. Federal aid to wildlife restoration. Southeast Idaho Wildlife Studies. Phosphate mining impacts on big game. Job progress report. Project W-160-R-9. Idaho Department of Fish and Game, Soda Springs. 355 pp. (ANALYZED DATA).

Location: IDFG, Soda Springs, Idaho. Cooperative Wildlife-Phosphate study area (950 mi² north and east of Soda Springs, including northeast Bear Lake County).

Evaluation: Design: PATREC (Pattern recognition habitat evaluation model) was used to predict loss of habitat potential to support big game, due to disturbances of phosphate-mining from 1960-2010. A similar approach was used to determine changes in potential due to natural succession. Timing: 1981-82. Analysis Methods: Computer habitat evaluation models. Data on potential big game losses presented graphically. Bayesian statistics used to synthesize habitat data into a form allowing estimate of suitability to support a given wildlife species.

Value to OIA Study: Conclusions: Phosphate mining activities on 2% of study area predicted to cause 2-6% loss of potential big game. However, habitat decline due to aspen stand degeneration is predicted to cause much greater loss, especially of mule deer summer and winter range (as much as 56%). Annualized loss of habitat potential is presented, for use in cost-benefit analysis, planning. Mining effects include removal of tree overstory, loss of heterogeneity due to revegetation methods, and changes in topography, due to resurfacing methods. A User's Handbook for PATREC is presented. Report is extension of material in Kuck 1981. Further Study: Apply PATREC to oil and gas exploration sites in OIA study area.

Subjective Rating of Document: Valuable predictive tool for assessing effects of natural succession, mining disturbance.

Heimer, J.T. 1973. Creel Census - Montpelier Creek Reservoir and Wood Canyon Reservoir. Idaho Department of Fish and Game. Pocatello, Idaho. 20 pp. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Conduct angler count - interview type creel censuses to estimate fishing pressure and catch. Total fishing effort was based on average anglers counted, hours fished per day, and days in period (calculated by two-week intervals). Timing: 1971-1972. Analysis Methods: Data tabulated.

Value to OIA Study: Conclusions: Counts were made on two reservoirs in Bear Lake County. Wood Canyon Reservoir is planted annually with rainbow trout. Montpelier Reservoir supports a cutthroat and rainbow fishery, since its creation in 1970. Baseline Data: Suitable as baseline for reservoir fishery in Bear Lake County.

Subjective Rating of Document: Valuable as indication of public interest in fishery, on two reservoirs on OIA study area.

Comments: Results:

location	cutthroat	rainbow	anglers inter- viewed	known hours fished	total fishing effort
Montpelier Creek Res. 1971	1.17 fish/hr	2.02	64	110	--
Montpelier Creek Res. 1972	1.14	0.45	671	997	7428
Wood Canyon Reservoir 1972	---	1.78	67	104	844

Heimer, J.T. 1974. Returns of planted rainbow trout, fishing pressure and catch in the Bear River and fish populations in mainstream reservoirs and tributary streams. Idaho Department of Fish and Game, Pocatello, Idaho. 50 pp. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Assessed returns of rainbow trout planted in the Bear River. Conducted an angler count-interview type creel census to estimate fishing pressure and catch. Assessed fish populations in tributary streams and mainstream reservoirs. Assessed factors which limit game fish populations. Reservoirs were surveyed with gill nets, streams by electrofishing. Analysis Methods: Data tabulated (Totals, percents).

Value to OIA Study: Conclusions: 900 anglers were counted on Bear River and reservoirs - 3% between Montpelier and Soda Springs, 0% from Montpelier to Wyoming border. Fishing pressure was estimated at 600 hours/year (early summer, fall), and 2000 hours (early winter, mouth of Thomas Fork), respectively. Catch was comprised mostly of rainbow and cutthroat trout. Electrofishing was done on Thomas Fork, Preuss Creek, Montpelier Creek and its tributaries, Georgetown Creek in Bear Lake County. Fish captured were hatchery rainbow, cutthroat, eastern brook, and brown trout, and mountain whitefish (2-4 species per stream). Water chemistry data was presented. The Bear River was found to be high in turbidity and nutrients, tributaries much less so. Baseline Data: Baseline data is limited for Bear River and tributary streams. Further Study: Recommendations were made for additional electrofishing surveys, and for maintaining and enhancing present native populations.

Subjective Rating of Document: Valuable information on fishery, angler interest in Bear River, valuable survey of tributaries.

Hemker, T.P. 1982. (Draft) Aspen succession and effects on mule deer, elk, and moose populations in southeastern Idaho. Unpublished report. Idaho Department of Fish and Game, Soda Springs. (ANALYZED DATA).

Location: IDFG, Soda Springs, Idaho. Cooperative Wildlife-Phosphate Study area (eastern Caribou County, northern Bear Lake County).

Evaluation: Design: Synthesis of information on aspen succession in West. Application to predictions of big-game populations from 1960 to 2010. Analysis Methods: Population estimates by Idaho Department of Fish and Game personnel.

Value to OIA Study: Conclusions: Value of aspen stands becomes limited when older than 70 years. Advent of fire suppression has led to decadent aspen stands throughout southeastern Idaho. Mule deer, moose, and to a lesser extent, elk are dependent on aspen at various times of year, and populations are expected to decline as much as 30% in the next 30 years. Mitigation of aspen decline can be achieved through clear-cutting, burning, or herbicides. Such mitigation may be a viable option open to mineral developers for offsetting mining impacts.

Subjective Rating of Document: Important assessment of problems associated with aspen succession. Describes mitigation procedures which may be suitable for use by mineral developers.

Henderson, D.M., F.D. Johnson, P. Packard, R. Steele. 1977. Endangered and threatened plants of Idaho - a summary of current knowledge. Bulletin 21. Forest, Wildlife, and Range Experiment Station, University of Idaho, Moscow. 71 pp. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello.

Evaluation: Design: Proposed list of endangered and threatened plant species in Idaho. Timing: 1977. Analysis Methods: None.

Value to OIA Study: Conclusions: One plant proposed from Caribou County. Cirsium davisii. Asteraceae. Proposed federal status - threatened, Idaho endemic. Land ownership in Bear Lake County-Caribou National Forest, 1 site each Bannock, Bonneville, Co. Found in sagebrush grass communities. Baseline Data: Valuable as baseline data. Exact distribution of species should be obtained from authors. Further Study: Distribution of species in Bear Lake County should be studied.

Subjective Rating of Document: Valuable baseline information on proposed threatened plant species on OIA study area.

Hennessy, S.P. 1978. Ecological relationships of accipiters in Northern Utah - with special emphasis on the effects of human disturbance. Thesis. Utah State University, Logan, Utah. (ANALYZED DATA).

Location: Utah State University Library (Special Collections), Logan, Utah.

Evaluation: Design: Examination of effects of habitat parameters and human disturbance on nesting success of goshawks, Cooper's and sharp-shinned hawks. Active hawk nests were located, listed by human disturbance category. 15 x 25m vegetation plots done at each nest. Recorded calls were used to locate breeding pairs. Pesticide analysis for eggshell thickness. Nest success determined. Timing: 1973-74. Analysis: Sample means, standard deviations. Discriminant function analysis. Principal components analysis, factor analysis. Correlation matrix, canonical correlation analysis. Multiple regression analysis.

Value to OIA Study: Conclusions: Accipiters tend to nest in large trees, near openings, roads or trails, and near water. These increase the probability of human disturbance. Detailed habitat information given for 32 nests in northern Utah (includes Rich Co.) and southern Idaho (Franklin Co.) Food-begging calls were sometimes successful for attracting adult birds. Human disturbance was a cause of unsuccessful nesting. DDT residues were found in eggshells. Baseline Data: Valuable information on nesting habitat. Further Study: Research should be used in planning recreation areas, roads, timber cuttings, and other human disturbances.

Subjective Rating of Document: Valuable information on accipiter habitat use, effects of human disturbance.

Hupp, J. and J. Connelly. 1982. Impacts of the proposed Tincup Loop Transmission line on avian species near the Lanes/Diamond Creek confluence. Unpublished report. 24 pp. (ANALYZED DATA).

Location: Soda Springs District Office, Caribou National Forest, Soda Springs, Idaho.

Evaluation: Design: Determine flight patterns of sandhill cranes and other waterfowl and shorebirds in relation to proposed transmission line route. Census sandhill cranes. Suggest ways of reducing impact on avian species. Flights were monitored during 12 1-hour periods on each of 5 segments (.1-.6 miles long). Species, direction and height of flight were recorded for each bird seen. Ground surveys were made for cranes and other waterbirds, on transects paralleling proposed route. Timing: June 1981. Analysis Methods: Data tabulated, percent of flight patterns crossing proposed route given. Height of flight patterns was analysed with χ^2 test of goodness of fit, with 95% confidence intervals.

Value to OIA Study: Conclusions: 29 species of birds were observed crossing proposed transmission lines. Proposed lines are believed to cause substantial impact on bird, especially sandhill cranes traveling between low, marshy areas and upland foraging sites. This would be especially important if whooping cranes become established with the sandhills at nearby Grays Lake Wildlife Refuge. Suggestions were made for best route selection, line configuration, and for placement of orange globes on line to improve visibility. Baseline Data: No value as baseline in Bear Lake County. Further Study: Suggested monitoring flight patterns after transmission line is constructed, censusing sandhill cranes in area in late spring and summer, and search for injured birds under the power line.

Subjective Rating of Document: Transmission lines may be necessary on the OIA area for power at exploration sites. Similar studies should be made near the Bear River Wildlife Refuge, and other marshy areas near Montpelier, Idaho.

Idaho Dept. of Fish and Game. 1979. Cooperative wildlife phosphate study, map: helicopter inventory, 1978-81. Unpublished map, IDFG, Soda Springs, Idaho. (MAPPING).

Location: Idaho Department of Fish and Game, Soda Springs.

Contact Person: Lonn Kuck (Senior Research Biologist)

Type of Map: Species Distribution.

Area Covered: Georgetown Front (Slug Creek Quadrangle 15'), Georgetown Canyon (Georgetown quadrangle 7-1/2').

Scale: 1:24000, 1:62500.

Evaluation: Species Included: Mule, deer, elk, moose - winter distribution. Distribution from field studies. Year of Original Mapping: 1979. Years Updated: 80, 81. Number of Years of Data: 3.
Subjective Evaluation of Mapping System: Intensive survey of water range in Caribou County, northern Bear Lake County.

Idaho Dept. of Fish and Game. 1977. Cooperative wildlife-phosphate study map: radio relocations. Unpublished map, IDFG, Soda Springs, Idaho. (MAPPING).

Location: Idaho Department of Fish and Game, Soda Springs.

Contact Person: Lonn Kuck (Senior Wildlife Biologist). Type of Map: Species distribution, overlay.

Area Covered: Cooperative Wildlife-Phosphate Study Area (Eastern Caribou and northern Bear Lake County).

Scale: 1:24000.

Evaluation: Species Included: mule deer, elk, moose - summer and winter ranges, migration routes, elk calving areas. Distribution from field studies. Year of Original Mapping: 1977-1982. Number of Years of Data: 5.

Subjective Evaluation of Mapping System: Very detailed set of radio-locations for over 100 animals. Data for Georgetown Summit in Bear Lake County.

Idaho Department of Fish and Game. 1981. Federal aid to wildlife restoration. Surveys and inventories: moose. Job progress report. Project W-170-R-4. Boise, Idaho, 39 pp. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Information on controlled moose hunt, population trends, herd composition. Data from check stations, telephone surveys, helicopter surveys. Timing: July 1979-June 1980. Analysis Methods: Data tabulated.

Value to OIA Study: Conclusions: Similar to Oldenburg and Medford (1982). Baseline Data: Data is collected each year in a similar manner. Can serve as baseline on Unit 76 (eastern Bear Lake and Caribou Counties).

Subjective Rating of Document: Best data on harvest success, winter counts of moose in Bear Lake County.

Idaho Department of Fish and Game. 1981. Federal aid to wildlife restoration. Surveys and inventories: mule deer. Job Progress Report. Project W-170-R-4. Boise. 322 pp. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Determine herd composition in early winter. Conduct counts on routes to estimate trends. Operate checking stations, telephone survey, to collect harvest data and biological samples. Measure extent of non-hunting winter-mortality. Timing:

July 1979-June 1980. Analysis Methods: Data tabulated.

Value to OIA Study: Conclusions: Helicopter survey of 494 deer.

Summary of herd composition 1972-1979. Data collected along Georgetown Front. Age data collected on 110 deer at Soda Springs and Montpelier check stations, also fawn weights, antler characteristics. Aerial survey counted 2550 deer, also elk, moose, coyote, golden eagles in February in southern Unit 76 (Bear Lake County). Data are broken down by sub-area. Deer in Bear Lake County believed to be producing better than in Caribou County. Harvest statistics for 1970-1979 presented. High winter-mortality recorded. Baseline Data: Data is collected each year, in a similar manner. Can serve as valuable baseline in OIA study area.

Subjective Rating of Document: Only available data on harvest success, winter counts of mule deer in Bear Lake County. Similar data to Oldenburg and Medford (1982).

Idaho Department of Fish and Game. File: Big Game aerial surveys.

Location: Idaho Department of Fish and Game, Pocatello, Idaho. (RAW DATA).

Contact Person: Bill Davidson (Regional Wildlife Manager).

Evaluation: Design: Data for each flight made in region. Not all actually big game, some Canada geese, waterfowl. Usually separated by management unit. Timing: 1975-1982.

Value OIA Study: Geographic Area Covered: Region 5 (6 counties, including Bear Lake county, Management Unit #76). Baseline Data: Some surveys made systematically each year: Canada Geese, waterfowl. Further Study: Surveys will be continued. Potential for Use in Wildlife Management: Valuable data on distribution, populations of big game major waterfowl species. Much of data collected elsewhere in region.

Subjective Rating of Document: Valuable information for management of big game, waterfowl, in Bear Lake County. Best data summarized in annual reports: surveys and inventories.

Idaho Department of Fish and Game. Files: Big Game Harvest, Check stations. (RAW DATA).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Contact Person: Bill Davidson (Regional Wildlife Manager).

Evaluation: Design: Big game harvest statistics. Most by original records. Check station reports, spot checks during hunting season. Timing: 1976-1982. Anticipated Completion Date: Ongoing.

Value to OIA Study: Geographic Area Covered: Region 5 (includes Bear Lake County). Baseline Data: Check station data collected same way each year, but dates, timing not systematic. Further Study: Data

will continue to be collected. Potential for Use in Wildlife Management: Valuable records, but very limited amounts from Bear Lake County (check station at Montpelier). Best data also reported in annual reports: Surveys and Inventories.
Subjective Rating of Document: Some value as background information for management of big game species.

Idaho Department of Fish and Game. File: Big Game Herd Composition. (RAW DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.
Contact Person: Bill Davidson (Regional Wildlife Manager).
Evaluation: Design: Records of herd composition by Management Unit. Observation by IDFG personnel. Date and location usually recorded. Timing: 1972-1976.
Value to OIA Study: Geographic Area Covered: Region 5 (includes Bear Lake County). Baseline Data: Data may not be collected systematically.
Subjective Rating of Document: Valuable information for management of big game species. Data summarized in annual reports: surveys and inventories.

Idaho Department of Fish and Game. File: Big Game Unit Summaries-Unit 76. (RAW DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.
Contact Person: Bill Davidson (Regional Wildlife Manager).
Evaluation: Design: Summaries of hunting season, harvest data, trend counts, aerial surveys, browse transects for elk, mule deer, moose. Same data as in annual reports: Surveys and Inventories. Timing: 1964-1975.
Value to OIA Study: Geographic Area Covered: Data collected same way each year, but timing, location not always standardized. Further Study: Data will continue to be collected. Potential for Use in Wildlife Management: Valuable data for management of big game species in Bear Lake County.
Subjective Rating of Document: Valuable information for management of big game species on OIA study area. Data, however, is also reported in annual report: Surveys and Inventories.

Idaho Department of Fish and Game. Files: Fisheries. (RAW DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.
Contact Person: Bill Davidson (Regional Wildlife Manager).
Evaluation: Design: Various information on fisheries (fish plants, surveys, creel censuses, changes in waterways, electrofishing, angler surveys, project proposals, correspondence). Timing: Some data back to 1941. Anticipated Completion Date: ongoing.

Value to OIA Study: Geographic Area Covered: Region 5, includes Bear Lake County. Only limited data from OIA study area. Baseline Data: Some data may be repeatable. Potential for Use in Wildlife Management: Some value in fisheries management. Best data has already been published elsewhere.

Subjective Rating of Document: Limited value for fisheries management on OIA study area.

Idaho Department of Fish and Game. File: Management Plans. Potential Endangered species (Bobcat, Otter). (RAW DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Contact Person: Bill Davidson (Regional Wildlife Manager).

Evaluation: Design: Comments on proposals to list bobcats and river otters as endangered or threatened. Timing: 1977.

Value to OIA Study: Geographic Area Covered: Statewide. General indications of population status in Bear Lake County. Maps of probable distributions. Further Study: Status of bobcats and otters should be monitored.

Subjective Rating of Document: Valuable information on status of two potentially endangered species on OIA study area. Should be considered in assessing impacts of oil and gas exploration.

Other Comments: Bobcats are in moderate numbers in eastern Bear Lake County. Bobcats appear to be in good numbers in many parts of the state. River otters are very uncommon, but could be expected in area.

Idaho Dept. of Fish and Game. n.d. File: Peregrine falcon study - southeast Idaho - field forms. Unpublished data sheets, IDFG, Soda Springs, ID. (RAW DATA)

Location: Idaho Department of Fish and Game, Soda Springs, Idaho. Cooperative Wildlife-Phosphate study area (950 mi² eastern Caribou County, northeastern Bear Lake County).

Contact Person: Lonn Kuck, Idaho Department of Fish and Game, Soda Springs.

Evaluation: Design: 35 potential nesting sites (cliffs) examined from air and ground. 10 active prairie falcon nests located, cliff sites described. Nesting sites of 7 other raptors located. Timing: April-June 1979. Anticipated Completion Date: Study completed, write-up date uncertain.

Value to OIA Study: Geographic Area Covered: Caribou County, northern Bear Lake County. Baseline Data: Cliff sites typically used over and over, although may not be used every year. Further Study: Similar survey in OIA study area would be valuable. Potential for Use in Wildlife Management: Important consideration in oil and gas exploration areas. Several raptors considered sensitive or endangered.

Subjective Rating of Document: Valuable survey of area. Similar results expected in Bear Lake County.

Comments: Includes 2 historic (presently inactive) peregrine falcon (endangered species) eyries, one near Montpelier, Bear Lake County.

Idaho Department of Fish and Game. 1975. File: Regional management plan - Beaver. Region 5, Pocatello, Idaho, 5 pp. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Provide management criteria for beaver, based on population information and qualitative discussion of management problems. Timing: 1975. Analysis Methods: None.

Value to OIA Study: Conclusions: Bear Lake and Caribou Counties support high densities of beaver, due to excellent quality habitat. Management on National Forest lands is for sustained yields and high populations, while intensive harvest on private lands is maintained to reduce depredation complaints. Problems in management are caused by fluctuating fur prices, inaccessibility of some production areas, carrying capacities exceeded by populations. Baseline Data: Not suitable. Further Study: Surveys should be conducted to evaluate current status of aspen and willow availability. Annual population estimates should be made on major streams.

Subjective Rating of Document: Some value as indication of problems, goals involved in management of beaver on OIA study area, under various land uses.

Idaho Department of Fish and Game. 1975. File: Regional Management Plan - Cottontail and pigmy rabbits. Region 5, Pocatello, Idaho. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Provides management criteria for rabbits.

Projection of population estimates, harvest data to 1990.

Qualitative discussion of habitat, management concerns. Estimates based on standard methods, harvest information. Timing: 1975.

Analysis Methods: Data tabulated (total, #/hunter, #/day).

Value to OIA Study: Conclusions: Cottontails are usually hunted incidentally to upland gamebirds. Populations are being affected by habitat losses. Changing agricultural practices (large, "clean" farms, cement ditches, weed control programs, elimination of hedgerows) are depleting habitat, as are agricultural encroachment in sagebrush areas and use of herbicides in willow and brush areas. Land use planners will be encouraged to leave weed patches, fencerows, and other habitat on public and private lands. Management will be towards increased populations, increased harvest. Population estimate for Bear Lake County - 12,000, harvest - 3,100. Baseline Data: Some value as baseline data. Further Study: Harvest information will continue to be collected.

Subjective Rating of Document: Indicates range of management problems with rabbits in Bear Lake County, resulting from various land uses.

Idaho Department of Fish and Game, 1975. File: Regional Management Plans-Upland game birds. Region 5, Pocatello, ID (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Provides management criteria for management of 7 upland game birds, 1975-1990. Projected populations size, harvest data given. Qualitative discussion of habitat, management concerns. Analysis Methods: Data tabulated (total, #/hunter, #/day). Basis for estimates not given.

Value to OIA Study: Conclusions: All species in Bear Lake County will be managed for increased population sizes, harvest levels. Most species are affected by agricultural encroachment, manipulations of natural vegetation, and livestock grazing interferences with nesting. Effects of habitat manipulation have been studied elsewhere for most species.

	<u>Preseason Population</u>	<u>Harvest</u>	<u>Habitat</u>
Sage Grouse	4000	2000	semi-arid sagebrush communities
Sharptailed grouse	few	few	rolling foothills, abandoned farmland, grasses and shrubs
Blue and Ruffed Grouse	12,500	6000	conifers, higher elevations. brushy deciduous cover, lower elevations.
Hungarian Partridge	900	300	dry, brushy patchwork lands.
Chukar	300	150	steep rocky terrain, brush, grasses & forbs.
Mourning dove	10,000	3700	Widespread.

Sagegrouse - small relic populations. Habitat loss due to agricultural encroachment, sagebrush removal (herbicides, brush eradication). Forbs mixed in reseeding mixtures helps. Livestock grazing removes nesting cover. Water may be restrictive. Sharptailed grouse - Small populations. Often unfarmable land or abandoned farmlands. Tolerates sagebrush removal. Habitat losses due to agricultural encroachment, overgrazing. Blue and Ruffed grouse - Difficult to collect data on. Heavy livestock grazing interferes with nesting and brooding areas. Hungarian partridge - Agricultural encroachment (clean, large farms, herbicides) have reduced habitat. Winters recently have been too severe in Bear Lake County. Chukar -

Mountain range, east side of Bear Lake. Heavy livestock grazing by sheep may impact nesting season. Water is restricted on many ranges. Mourning dove - Agricultural encroachment and wildfires cause habitat loss. Baseline Data: Limited value as estimate of populations in Bear Lake County. Further Study: Additional information on critical areas (breeding grounds, brood production areas, wintering areas) and harvest would be valuable.

Subjective Rating of Document: Valuable discussion of management concerns with upland game birds on OIA study area.

Idaho Department of Fish and Game, Files: Upland Game. (RAW DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Contact Person: Bill Davidson (Regional Wildlife Manager).

Evaluation: Design: Various information on 8 upland game species.

Includes harvest information on 8 upland game birds. Specific census techniques include pheasant crow counts (since 1963), dove call counts, sage grouse booming counts (1978-81). Harvest data generally from elsewhere in Region, especially pheasant check stations. Data is available for sage grouse in Bear Lake County - lek census at Geneva Cemetery and others, maps, sex-age data. Banding records. Timing: 1974-1982. Anticipated Completion Data: Ongoing.

Value to OIA Study: Geographic Area Covered: Region 5. Very little harvest data for Bear Lake County. Further Study: Data will continue to be collected. Potential For Use in Wildlife Management: Some value in management of upland game.

Subjective Rating of Document: Data of limited value in Bear Lake County. Some information on sage grouse strutting areas, which should be considered in assessing impacts on OIA study area.

Idaho Department of Fish and Game. Files: Waterfowl. (RAW DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Contact Person: Bill Davidson (Regional Wildlife Manager).

Evaluation (Studies in Progress Only): Design: Various information on waterfowl species. Most data collected along Snake River, but some on Bear River, Bear River Refuge. Specific data include banding data, Canada goose breeding surveys (more detailed than Krohn 1976), duck nesting survey, fall-winter aerial surveys, harvest records. Limited data on long-billed curlews, sandhill and whooping cranes, trumpeter swans, waterfowl diseases, pesticides, mercury, lead shot. Timing: 1974-1982. Anticipated Completion Data: Ongoing.

Value to OIA Study: Geographic Area Covered: Region 5 (6 counties, including Bear Lake). Baseline Data: Most surveys made using repeatable methods. Further Study: Data will continue to be collected. Potential For Use in Wildlife Management: Some value in assessing numbers, seasonality of waterfowl.

Subjective Rating of Document: Valuable data for management of waterfowl on OIA study area.

Idaho Department of Fish and Game. 1975. File: Waterfowl - Regional management plans, Region 5, Pocatello, ID. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Provides management criteria for Canada geese, ducks, Wilson's snipe, American coots. Nesting, migration, and winter surveys taken - ground and aerial. Timing: 1975. Analysis Methods: Population estimates given, and projected to 1980. Estimates based on standard methods, surveys, harvest information.

Value to OIA Study: Conclusions: All 4 groups will be managed for increased population levels, increased harvest. Waterfowl are a heavily utilized resource in Region and in Bear Lake County. Primary thrust of management will be encouraging practices to increase production on public and private lands. Marshlands will be purchased or incentive programs developed for maintaining marsh lands. Lack of production areas is seen to be a major limiting factor in population size. Methods for improving nesting, brood habitat include nesting platforms, dikes, and artificial islands to protect nest from high runoff waters, also protection of habitat from agricultural encroachment. Canada Geese - not present in winter due to frozen waters. Idaho Great Basin - major production and harvest areas. Other geese very incidental. Ducks - produced wherever water and cover available. Some winter on open water. Wilson's snipe - Harvest mostly incidental to waterfowl. Winter on open springs. Coots - Not preferred by hunters. Not present in winter.

Bear Lake County	Fall pop'n	Winter pop'n	harvest
Canada geese	2,500	---	1500
Ducks	10,500	200	8500
Wilson's snipe (Region)	10,000	few	1400
Coot	15,000	---	2600

Baseline Data: Could be used for gross level baseline. Further Study: Better surveys, additional banding recommended. Harvest information will continue to be collected.

Subjective Rating of Document: Indicates range of waterfowl management problems resulting from various land uses on Bear Lake County.

Idaho Department of Fish and Game. File: Wolf. (RAW DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Contact Person: Bill Davidson (Regional Wildlife Manager).

Evaluation: Design: Records of three unsubstantiated sightings and probable killings by wolves (1982 - Tincup Canyon, 1981 - Grays Lake - 1979 - Lava Hot Springs areas). Timing: 1979-1982.

Value to OIA Study: Geographic Area Covered: Region 5 (includes areas in Caribou and Bannock counties). Baseline Data (Repeatability): not suitable. Further Study: Status should be monitored. Potential For Use in Wildlife Management: Wolf range appears to be expanding away from central Idaho and Yellowstone areas.

Subjective Rating of Document: Some value as indication of wolves' expanding range.

Idaho Department of Fish and Game. 1974. Interagency guidelines for big game range investigations in Idaho. Idaho Department of Fish and Game, Bureau of Land Management, Forest Service. 54pp. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Description and evaluation of big game range study techniques used by above agencies. Instructions for carrying out techniques. Timing: 1974. Analysis Methods: None.

Value to OIA Study: Conclusions: Descriptions of methods given, with advantages and disadvantages: location of key areas, aerial and ground observations, browse transects, pellet group transects. Attempts to standardize agency research with high-quality methods. Importance of training emphasized. Baseline Data: Not suitable.

Subjective Rating of Document: Useful description of big game range methods, as used in Idaho. Methods should be used for assessing big game habitat on OIA study area.

Idaho Department of Fish and Game. LANDSAT satellite vegetation maps (color).
(MAPPING)

Location: Idaho Department of Fish and Game, Soda Springs, Idaho.

Contact Person: Lonn Kuck (Senior Wildlife Biologist)

Type of Map: Habitat

Area Covered: Cooperative Wildlife-Phosphate study area (eastern Caribou County, northern Bear Lake County, 950 mi²).

Scale: 1:62500

Evaluation: Habitat Types Mapped: 12 vegetation types mapped derived from LANDSAT satellite data (see Kvale and Wood 1980, Kvale 1982).

Resolution: 1.1 acre pixels. Ground Truthed? Yes. Number of Seasons: 1.

Subjective Evaluation of Mapping System: Valuable tool for analyzing vegetation types, can be extended to Bear Lake County.

Comment: Completed for Cooperative Wildlife-Phosphate study area. Data also available for part of Bear Lake County, but not ground-truthed.

Data can be converted easily to acres per vegetation type with computer program.

Idaho Department of Fish and Game. LANDSAT satellite vegetation maps (Digital). (MAPPING)

Location: Idaho Department of Fish and Game, Soda Springs, Idaho.

Contact Person: Lonn Kuck (Senior Wildlife Biologist).

Type of Map: Habitat

Area Covered: Cooperative Wildlife-Phosphate study area (eastern Caribou, northern Bear Lake Counties, 950 mi²).

Scale: 1:24000

Evaluation: Habitat Types Mapped: 17 vegetation types mapped, derived from LANDSAT satellite data (see Kvale and Wood 1980, Kvale 1982).

Resolution: 1.1 acre pixels. Ground Truthed? Yes.

Subjective Evaluation of Mapping Systems: Satellite imagery is a valuable tool for analyzing vegetation types, can be extended to include Bear Lake County.

Comment: Completed for Cooperative Wildlife-Phosphate study area. Data also available for part of Bear Lake County, but not ground-truthed.

harvested in 1990 under the plan. Specific problems identified were: 1) increased illegal harvest, especially in conjunction with increased human activity, 2) land-use conflicts and loss of habitat, 3) inadequacy of baseline data on population size and dynamics, movements and seasonal distribution, and harvest, 4) increased vulnerability from removal of hiding cover, and 5) declining quality of moose habitat due to succession of productive aspen forest towards conifers. Baseline Data: Some values as baseline data, although not confined to study area.

Subjective Rating of Document: Indicates range of problems involved in moose management. Long range goals for area, resulting from various land uses.

Idaho Department of Fish and Game. 1982. (Draft). A plan for managing Idaho's black bear and mountain lion resources in 1981-1985. Boise, ID. 59pp. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Pocatello, ID.

Evaluation: Design: Provide management criteria for black bear and mountain lion in next five years, based on population characteristics and management problems. Timing: Based on information available prior to 1982. Analysis Methods: Population and harvest estimated given, based on harvest data.

Value to OIA Study; Conclusions: Estimated population: 2075 black bear, 190 harvested in 19,900 hunter-days; estimated 75 mountain lion, 2 harvested in 50 hunter-days, in southeastern Idaho. Demand is expected to increase. Present goals are to maintain the mountain lion population, while increasing harvest and recreational opportunity. Specific problems identified were 1) poor information available on population dynamics, and harvest levels (information is available in northern part of state), 2) conflicts with other land uses, primarily livestock owners, 3) increased illegal kill, especially resulting from increased human population and increased access. Legal harvest can also be expected to increase with increased access. Baseline Data: Possible baseline data, but not reported for small area.

Subjective Rating of Document: Indicates range of problems involved in management of these species. Long range goals of area, based on various land uses.

Idaho Department of Fish and Game. 1978. A plan for the future management of Idaho's fish and wildlife resources. Goals, objectives and policies 1975-1990. Vol. 1. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Provides clear policies and strategies to guide the Department in development of future management programs. Data is presented on estimated statewide population size, harvest, and expected demand. Population estimates are derived using a variety of standard methods. Timing: 1977. Analysis Methods: Data tabulated.

Value to OIA Study: Conclusions: General policies, problems, and strategies for mitigation are listed for 5 big game species, 8 upland game species, waterfowl, furbearers, non-game and "species of special concern", for fisheries and invertebrate groups. Demand is expected to increase for all groups. Habitat is generally declining due to urban, agricultural, or industrial development. Therefore, better management will be necessary to sustain population and meet harvest goals. Information will be further developed in management plans for various species. Policies generally suggest further investigation of habitat requirements, protection and enhancement of existing habitat. Species of special concern in Bear Lake County are: bobcat, lynx, whooping crane, sharp-tailed grouse, trumpeter swan, ferruginous hawk, prairie and peregrine falcons, Bear Lake cutthroat Bear Lake sculpin, Bear Lake whitefish, Bonneville whitefish, Bonneville cisco. Baseline Data: Statewide data, not suitable as baseline. Further Study: Further study of many items desirable. Survey data on animal populations, harvest, and habitat requirements are inadequate for making management decisions.

Subjective Rating of Document: Indicate range of concerns and problems faced in management of Idaho's fishery and wildlife resources.

Idaho Department of Fish and Game. 1982. (DRAFT) A plan for managing Idaho's pronghorn antelope, moose, bighorn sheep, and mountain goat resources in 1981-1985. Boise, ID. 151 pp. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Provide management criteria for moose during next 5 years, based on population characteristics and management problems.

Timing: Based on information prior to 1982. Analysis Methods:

Population and harvest given. Based on harvest estimates, aerial surveys, etc.

Value to OIA Study: Conclusions: Moose are an important resource in Unit 76 (eastern Bear Lake, Caribou Counties) and the population is expanding. High demand is expected to continue. Present goals are to increase population size, increase harvest, and provide more recreation. Estimated population 550 moose on Unit, 1981. 36 harvested in 200 hunter-days. Specific problems identified were: 1) increased illegal harvest, especially in conjunction with increased human activity, 2) land-use conflicts and loss of habitat, 3) inadequacy of baseline data on population size and dynamics, movements and seasonal distribution, and harvest, 4) increased vulnerability from removal of hiding cover, and 5) declining quality of moose habitat due to succession of productive aspen forest towards conifers. Baseline Data: Some value as baseline data, although not confined to study area.

Subjective Rating of Document: Indicates range of problems involved in moose management. Long range goals for area, resulting from various land uses.

Idaho Department of Fish and Game. 1982. Species management plan - Elk, 1981-1985. Boise, Idaho. 89pp.

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Provide management criteria for elk during next five years, based on population characteristics and management problems. Timing: Based on information prior to 1981. Analysis

Methods: Population and harvest estimates given, based on harvest, aerial surveys, etc.

Value to OIA Study: Conclusions: Elk are an important resource in Unit 76 (eastern Bear Lake, Caribou Counties), and there is a high ratio of hunters to elk. Demand is expected to increase. Present goals are: Maintain population size, increase harvest, and provide more recreation. Estimated population 1600 elk in Unit 76, 1981. 160 elk harvested in 2100 hunter/days. Specific problems identified are: 1) conflicts with other land uses, especially roads, 2) increased illegal harvest, especially in conjunction with increasing human population and road access, 3) inadequacy of baseline data on population size and dynamics, movements and seasonal distribution, and harvest, 4) succession of seral aspen forests towards conifers, reducing value of habitat to elk. Baseline Data: Possible baseline, although not restricted to study area.

Subjective Rating of Document: Indicates range of problems involved in elk management. Long-range goals for area, based on various land uses.

Idaho Department of Fish and Game, 1982. Species management plan - mule deer, 1981-1985, Boise, ID. 120pp. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Provide management criteria for elk during next five years, based on population characteristics and management problems. Timing: Based on information prior to 1981. Analysis

Methods: Population and harvest estimates given. Based on harvest estimates, aerial surveys, etc.

Value to OIA Study: Conclusions: Unit 76 (eastern Bear Lake and Caribou Counties) is highly productive for mule deer. Demand is expected to increase. Present goals are to increase mule deer numbers.

Mitigation of habitat loss will probably be necessary for this goal.

Estimated population: 9000 mule deer in Unit 76, 1981. 2,200 harvested in 32,000 hunter-days. Specific problems identified area: 1) conflicts with other land uses, especially roads and phosphate mining, 2) increased illegal harvest, especially in conjunction with increasing human population and road access, 3) inadequacy of baseline data on population size and dynamics, movements and seasonal distributions, and harvest rates, 4) habitat degradation due to succession of seral aspen forests to conifers, 5) severe winters with regularly occurring winter loss requiring undisturbed winter range.

Evaluation (Studies in Progress Only): Design: Breakdown of habitat across in Region 5 and in Bear Lake County. Computer printout presented by County (Bear Lake), watershed (Bear River), management unit (76), habitat class (31 divisions: tall sagebrush, bitterbrush-shrub

Baseline Data: Some value as baseline data, although not restricted to study area.

Subjective Rating of Document: Indicates range of problems involved in mule deer management. Long-range goals for area, resulting from various land uses.

Idaho Department of Water Resources. 1976. Summary report - Conclusions and recommendations for the State Water Plan - Part II, Bear River Basins, Boise, Idaho. 73pp. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: To prepare an inventory of water resources of Idaho, ascertain means of conserving and augmenting these, and determine most effective means to apply them for benefit of people of Idaho. Timing: 1976. Analysis Methods: none.

Value to OIA Study: Conclusions: Wildlife and fishery value may be impacted by low stream flows on the Bear River. While all water flow at low levels is previously claimed, minimum flows are guaranteed by prior agreements between Utah Power and Light and Utah-Idaho Sugar Company. These amounts do not, however, always meet recommended flows by IDFG. Drawing down Bear Lake to supply Bear River fishery would impact the lake fishery. Preservation and enhancement of stream and reservoir fisheries will be considered as important concerns. Baseline Data: not suitable. Further Study: Recommends program be established with IDFG to adopt management criteria for fish and wildlife resources on all principle streams and wetlands.

Subjective Rating of Document: Valuable indication of management problems of fisheries on OIA study area.

Idaho Department of Fish and Game. 1981. Federal aid to wildlife restoration. Elk surveys and inventories. Job Progress report. Project W-170-R-4. Boise, ID. 219pp. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Results of elk surveys and inventories. Composition counts, trend counts, Harvest data - check station, telephone survey. Timing: July 1979 - June 1980. Analysis Methods: Data tabulated. Composition data with Bull:Cow:Calf ratios.

Value to OIA Study: Conclusions: Population on Unit 76 (eastern Bear Lake, Caribou Counties) is on upward trend. Composition counts (43 B: 100 C:39c) indicate healthy population. Long-range detrimental impacts, however, are expected from increasing industrial development, expected to impact elk winter range and calving areas. Base population 1000, (fall 1200). 139 killed (42% success) in 1979.

Subjective Rating of Document: Best available documentation of elk population, harvest on OIA area.

Idaho Department of Fish and Game. 1979. Federal aid to wildlife restoration. Surveys and inventories: Furbearer management. Job progress report. Project W-170-R-3. Boise, ID. 72pp. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Pocatello.

Evaluation: Design: Determine population status and harvest of furbearers in Idaho, by species, region, and county. Harvest was extrapolated from reported trapper harvest (6890 reporting). Value of harvest statewide given, beaver colony counts made, trends noted. Habitat quality of trend streams (Montpelier creek) assessed, based on three factors: physical features, availability of food species, water supply. Timing: July 1978 - June 1979. Analysis Methods: Data tabulated.

Value to OIA Study: Conclusions: Nine species were trapped in Bear Lake County - 499 beaver, 2059 muskrat, 126 mink, 3 raccoon, 41 fox, 10 bobcat, 38 weasel, 47 coyote, 352 badger, 51 trapping licenses were purchased. Harvest was up 11% from previous year. 66 wildlife depredations were reported (44 by beaver). Montpelier Creek is rated fair beaver habitat. 3-6 colonies have been present since survey began in 1965 (6 miles surveyed). Baseline Data: Harvest data, beaver colony counts will serve as baseline information. Further Study: Studies are continued each year.

Subjective Rating of Document: Valuable documentation of furbearer populations on OIA study area.

Idaho Department of Fish and Game. State Planning Map - Region 5. (MAPPING)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Contact Person: Bill Davidson (Regional Wildlife Manager)

Type of Map: Habitat (overlay).

Area Covered: Bear Lake County (and others).

Scale: 1" - 4 miles.

Evaluation: Habitat Types Mapped: 25 vegetation/agriculture/urban habitat classes. Overlays for ownership, roads, streams, vegetation.

Resolution: 1/2 mile diameter. Ground Truthed? Unknown. Year of Original Mapping: 1973. Years Updated: 0.

Subjective Evaluation of Mapping System: Detailed habitat map of Bear Lake County. Should be considered in assessing impact to wildlife habitat caused by oil and gas exploration.

Idaho Department of Fish and Game, 1975. Wildlife Resource Inventory: Region 5 Summary; Bear Lake County. (RAW DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Contact Person: Bill Davidson (Regional Wildlife Manager).

Evaluation (Studies in Progress Only): Design: Breakdown of habitat acres in Region 5 and in Bear Lake County. Computer printout presented by County (Bear Lake), watershed (Bear River), management Unit (#76), habitat class (33 divisions; tall sagebrush, bitterbrush-shrub steppe, aspen, wet meadows, urban, etc.) Within each habitat type in each unit, abundance of animal species is assessed. Each species is rated high, medium, low, absent, or unknown (30 mammals, 192 birds, 15 amphibians, 23 reptiles). Each is rated for each season. Timing: 1974-1975. Anticipated Completion Date: Completed.

Value to OIA Study: Geographic Area Covered: Done for each county in state. Presented separately for Bear Lake County, and Region 5 (Bannock, Bear Lake, Bingham, Caribou, Franklin, Oneida, Power Counties). Potential For Use in Wildlife Management: Valuable information on presence of various habitat types on OIA study area, wildlife species present.

Subjective Rating of Document: Valuable information on presence of various habitat types on OIA study area. Should be considered in assessing wildlife habitat loss from oil and gas exploration.

Jenni, D.A., R.L. Redmond, and T.K. Bicak. 1982. Behavioral ecology and habitat relationships of long-billed curlew in western Idaho. Bureau of Land Management, Boise, ID. 234pp. (ANALYZED DATA)

Location: Soda Springs Resource Area Headquarters, Bureau of Land Management, Soda Springs, Idaho.

Evaluation: Design: Determine density and distribution of long-billed curlews on major breeding area along the western Snake river, along environmental gradients. Inventory vegetation, structure, topography, and management regimes. Study ecology and breeding behavior, limiting factors, effects of disturbances. Radio telemetry color-banding (N=312). Line-transect flush surveys. Vegetation transects for cover and structure. Analysis Methods: Totals, means, standard deviation, confidence intervals. Regression analysis, correlation coefficients. Spearman rank correlation coefficient.

Value to OIA Study: Conclusions: Extensive information on breeding behavior and ecology of long-billed curlews. Vegetation characteristics of habitat selected. Grazing by cattle and sheep was believed advantageous - no breeding curlews were observed except where grazing had occurred within 1 year. Fall burning also enhanced breeding habitat. Use by off-road vehicles, human activity, dust from roads, all had significant impacts on breeding success. Baseline Data: No value as baseline on OIA study area. Habitat selection, effects of disturbance, however, should apply due to fairly specific habitat requirements. Further Study: Numbers, distribution of curlews in Bear Lake County should be determined.

Subjective Rating of Document: Information on habitat selection, disturbances should be applied to long-billed curlew nesting in Bear Lake County. Species is classified "sensitive" by BLM, IDFG.

Jensen, D. 1964. Federal aid to wildlife restoration. Effects of hunting pressure in deer and elk herd management units 70 to 78 inclusive. Completion report, Project W-85-R-15, Idaho Department of Fish and Game, Boise, ID. 63pp. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Soda Springs, Idaho.

Evaluation: Design: Various data on deer, elk, and moose summarized from 1951-1964. Browse utilization transects (3 on OIA study area), trend counts, winter kill, harvest, age and sex of harvested deer checked, deer weights, movements of 300 tagged deer, migration routes, etc. Timing: 1963-1964. Analysis Methods: Data tabulated (some means, %, graphs).

Value to OIA Study: Conclusions: Information summarized for all aspects of big game management. Baseline Data: May serve as baseline data for Unit 76 (eastern Bear Lake, Caribou Counties). Further Study: Various recommendations for management were given.

Subjective Rating of Document: Valuable documentation of historical big game management on OIA study area.

Keith, J.E. 1971. An economic analysis of the cisco fisheries of Bear Lake, Utah and Idaho. Thesis. Utah State University, Logan, Utah. (ANALYZED DATA)

Location: Utah State University Library, Logan, Utah.

Evaluation: Design: Economic analysis of Cisco harvest.

Willingness-to-pay data were collected by personal interview each day of the 1970 Cisco run, opportunity cost of time was calculated and examined as part of total costs of fishing, coefficients of income and opportunity costs of time were compared. Timing: Jan. 14-20, 1970.

Analysis Methods: Total use is calculated from sampling percentages. Demand is calculated. Regression analyses, statistical models used.

Value to OIA Study: Conclusions: Opportunity cost of time found to be a significant factor in consumer's participation and affected the valuation of the recreation considerably. Coefficients of income and opportunity costs were found to be of different sign for rural counties indicating a difference between the two variables. Further Study: Further refinement of the opportunity cost of time is needed. The concept of time costs has not been empirically evaluated for a recreation good.

Subjective Rating of Document: Some management value for Cisco fishery on Bear Lake policy implications of increased fishing pressures.

Krohn, W.B. 1976. (Draft) An inventory of Canada goose habitats in the Rocky Mountain Region. Idaho Cooperative Wildlife Research Unit, University of Idaho, Moscow. 92pp. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

King, S. and A. Muir. 1971. Big game range inventory 1969-1970. UDWR Publication No. 71-3. Project W-69-R-18, dated June 1971, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: See Coles and Pederson (1967)

Value to OIA Study: Baseline Data: Provides valuable baseline data for deer herd unit 2 (acre) and for deer herd unit 5 (Woodruff). See Figure 1.

Type of Map: Habitat

Area Covered: Deer herd units 2 (Cache) and 5 (Woodruff)

Scale: varies, no scales given on maps.

Evaluation: Habitat Types Mapped: Sagebrush, sparse sagebrush, browse, juniper, sagebrush-grass, agricultural land, reseeding (preceding mapped on winter range only), winter range (upper, lower, and severe winter limits) and migration routes. Resolution: habitat types: about 40 acres, seasonal ranges: about 30 acres, migration: 1/3 mile. Ground Truthed? Yes. Number of Seasons: 1.

Subjective Evaluation of Mapping System: Lack of scale and small size of maps limits value somewhat, but the maps are useful to reference the text.

King, S. and B. Olson. 1972. Big game range inventory 1970-1971. UDWR Publication. No 72-10, Project W-65-R-20, dated Sept. 72, Salt Lake City, Utah. (ANALYZED DATA)

Location: University of Utah, UDWR

Evaluation: See Coles and Pederson (1967)

Value to OIA Study: Conclusions: Contains data on Unit 6 (Lost Creek), and Unit 24 (Blacks Fork) in the study area. Also has data on 4 other units outside the study area (Ogden, Davis County, Salt Lake, and North Book Cliffs) See Figure 1. Baseline Data: Provides baseline data for 3 deer herds in the area.

Subjective Rating of Document: Valuable data on 3 deer herds are in this report.

Leatham, J.P., and S.D. Bunnell. 1979. Utah upland game annual report 1978. UDWR Publication 79-12, Project W-65-R-D-27, Job A-4, Salt Lake City, Utah. ANALYZED DATA

Location: University of Utah, UDWR.

Evaluation: See UDWR (1965).

Evaluation: Design: Documents amount and distribution of nesting, molting, and wintering habitat in Intermountain West. Assesses its ability to support management goal of 50,000 wintering geese. Literature review, cooperator survey forms (five-year counts, mean and maximum on all areas). Timing: 1976. Analysis Methods: Data tabulated (acreages, mean, maximum goose numbers).

Value to OIA Study: Conclusions: Southeastern Idaho is one of three major Canada goose production areas in the Intermountain Region, producing nearly 1/3 of the total. Flooded bottom lands are a major nesting habitat and are subject to degradation by mineral exploration. Bottomlands between Grays Lake NWR and Bear Lake NWR especially noted. Not used by wintering or molting populations. Baseline Data: Baseline data suitable for use in Bear Lake County.

Subjective Rating of Document: Some value as estimate of general location, number of nesting Canada geese.

Comment: Summary of data was published as Krohn, 1977. The Rocky Mountain population of the western Canada goose: Its distribution, habits, and management. Dissertation. University of Idaho, Moscow, 299pp. Also Krohn and Bizeau. 1980. USFWS Special Report - Wildlife No. 229. 93pp.

Habitat	Area	Mean, Max.	Vegetation Types
Nesting	Southeast Idaho	1900 pairs	Flooded bottomlands, river reservoirs, marshes,
	Bear River (Bear Lake, Caribou counties)	114,240	
	Bear Lake NWR	335,545	
	Thomas Fork River	---, 15	

Kuck, L. 1979. Federal aid to wildlife restoration. S.E. Idaho Wildlife Studies. Endangered raptors. Job Prog. Rep. W-160-R-6. Idaho Dept. Fish and Game Soda Springs, Idaho. 95pp. (ANALYZED DATA)

Location: IDFG, Soda Springs Idaho. Cooperative Wildlife-Phosphate Study area (950 mi² north and east of Soda Springs) and 3 adjacent lakes and reservoirs. Includes northern Bear Lake County.

Evaluation: Design: Determine the presence and status of endangered raptors within the phosphate area of S.E. Idaho. Aerial survey of potential nesting sites, road and snowmobile census. Food habits analysis from pellets. Timing: July 1978 - June 1979. Analysis Methods: Data tabulated, presented geographically.

Value to OIA Study: Conclusions: Bald eagles were observed during spring (up to 60 birds) and fall migrations (23), and wintered on the area (7). No active nests were found. Peregrines were sighted 3 times 1976-79, but no active nests were found. Baseline Data: Eagle hunting and feeding areas and roosting sites were identified, one area was in Bear Lake County. Further Study: Similar surveys should be made throughout Bear Lake County.

Subjective Rating of Document: Intensive survey of area. Includes northern Bear Lake County. Similar distributions likely throughout Bear Lake County, consequently valuable for management of these species.

Comments: Eagle breeding habitat was limited, although 2 nests were active at least until 1973 near the study area. Most eagles were located along shores of open water -- rivers or reservoirs. Roosting sites were on adjacent hillsides. Bald eagles were located in Georgetown Canyon, Bear Lake County (0-2 during winter and during spring migration). Open water was minimal there, and eagles fed on winter-killed mule deer.

Kuck, L. 1979. Federal aid to wildlife restoration. S.E. Idaho Wildlife Studies. Endangered raptors. Job Prog. Rep. W-160-R-6. Idaho Dept. Fish and Game, Soda Springs, Idaho 95pp. (MAPPING)

Location: Idaho Department of Fish and Game, Soda Springs, Idaho.

Contact Person: Lonn Kuch, Idaho Dept. of Fish and Game, Soda Springs, Idaho.

Type of Map: Species Distribution

Area Covered: Georgetown Canyon, Bear Lake Canyon (and elsewhere in Caribou County)

Scale: 1/2" = 1 mile

Evaluation: Resolution: .5 mile. Ground Truthed? Yes. Number of Seasons: 3. Species Included: Northern Bald Eagle (hunting and feeding area). Distribution from Field Studies. Year of Original Mapping: 78-79. Years Updated: 0. Number of Years of Data: 1.

Subjective Evaluation of Mapping System: Based on road census along drainage bottom, valuable for determining locations of sensitive areas for planning purposes.

Kuck, L. 1979. Federal aid to wildlife restoration. Southeast Idaho Wildlife Studies. Phosphate mining impacts on big game - Wildlife inventory of Middle Sulphur Canyon. Job Progress report. Project W-160-R-6. Idaho Department of Fish and Game, Boise, Idaho. 153pp. (ANALYZED DATA)

Location: IDFG, Soda Springs, Idaho. Cooperative Wildlife-Phosphate study area - Middle Sulphur Canyon mine site (7 mi east of Soda Springs, 3 mi north of Bear Lake County). IDFG Soda Springs

Evaluation: Design: Determine seasonal use patterns, distribution, abundance of big game, upland game birds, predators, raptors, endangered species on proposed mine site. Foot, road, snowmobile survey. Helicopter survey, radio-telemetry of big game. Timing: Jan. 1977 - Dec. 1978. Analysis Methods: Data tabulated. Species lists, number sighted per month presented by season, vegetation type.

Value to OIA Study: Conclusions: 3504 wildlife observations - 3 reptile species, 62 bird spp., 21 mammal spp. 14 spp. of raptors, (3 spp. nesting). 2 Bald eagles seen. Blue and ruffed grouse, mourning doves. Evidence of black bear, mt. lion, 5 furbearers. Area was critical winter range for big game. Seasonal ranges, migration routes, elk calving areas were identified. Baseline Data: Can be used as baseline for low-elevation, winter-range areas in Bear Lake County.

Subjective Rating of Document: Because of closeness (some overlap) and similarity of habitats to Bear Lake County, similar results would be expected there.

Kuck, L. 1981. Computer implementation. Pages 175-242 in L. Kuch and E.H. Merrill. Federal aid to wildlife restoration. Southeast Idaho Wildlife Studies. Phosphate mining impacts on big game. Job Progress Report, Project W-160-R-9 Idaho Department of Fish and Game. Soda Springs, Idaho. 70pp. (ANALYSED DATA)

Location: IDFG, Soda Springs, Idaho. Cooperative Wildlife-Phosphate study area (950 mi² north and east of Soda Springs, Idaho).

Includes northern Bear Lake County. IDFG, Soda Springs.

Evaluation: Design: Use a wildlife management information system to predict and minimize the impacts of phosphate mining in southeastern Idaho. Pattern Recognition (PATREC) habitat evaluation models for 3 species, summer and winter range. Timing: 1979-1981. Analysis Methods: Known population densities (helicopter census) were used to predict densities on unsurveyed areas. Bayesian probabilities were used to estimate extent to which high and low densities could be supported.

Value to OIA Study: Conclusions: Summer and winter habitat models were made for mule deer and elk, year-round for moose. Models adequately predicted densities on known areas. Baseline Data: Because of closeness and similar habitat types, model should apply with minimal loss of accuracy to population densities in Bear Lake County. Data has already been incorporated from Georgetown front area of Bear Lake County. Further Study: Model should be applied to Bear Lake County.

Subjective Rating of Document: Valuable predictive tool. Based on extensive population census and habitat utilization survey.

Comments: PATREC model was designed to predict big game populations affected by proposed habitat alterations. Preliminary, untested habitat models are also available for ruffed grouse, prairie falcons, and sandhill cranes (J. Jengo, M.S. Thesis, In prep., Colorado State University; also Kuck et al. 1980)

Kuck, L. 1981. Federal aid to wildlife restoration. Southeast Idaho Wildlife Studies. Phosphate mining impacts on big-game-computer implementation. Job Progress Report. Project W-160-R-9. Idaho Department of Fish and Game. Soda Springs, Idaho. 70pp. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Soda Springs

Evaluation: Design: A wildlife management information system was used to predict and minimize the impacts of phosphate mining in southeastern Idaho. Cooperative Wildlife-Phosphate study area (950 mi north and east of Soda Springs, Idaho). Includes northern Bear Lake County. Pattern Recognition (PATREC) habitat evaluation models for 3 species, summer and winter range. Known population densities (helicopter census) were used to predict densities on unsurveyed areas. Timing: 1979-1981. Analysis Methods: Bayesian statistics were used to estimate extent to which high and low big game densities could be supported.

Value to OIA Study: Conclusions: Summer and winter habitat models were made for mule deer and elk, year-round for moose. Models adequately predicted densities on known areas. Baseline Data: Because of closeness and similar habitat types, model should apply with minimal loss of accuracy to population densities in Bear Lake County. Data has already been incorporated from Georgetown front area of Bear Lake County. Further Study: Model should be applied to Bear Lake County.

Subjective Rating of Document: Valuable predictive tool. Based on extensive population census and habitat utilization survey.

Comment: PATREC model was designed to predict big game populations affected by proposed habitat alterations.

Kuck, L., C.T. Kvale, E.H. Merrill, J.A. Ellis, and J. Jengo. 1980. Federal aid to wildlife restoration. Southeast Idaho Wildlife Studies. Job Progress Report. Project W-160-R-7. Idaho Department of Fish and Game, Soda Springs. 223 pp. (ANALYZED DATA)

Location: IDFG Soda Springs, Idaho. Cooperative wildlife-phosphate study area (950 mi² eastern Caribou County, northern Bear Lake County).

Evaluation: Design: Determine mule deer, elk, and moose movement patterns, habitat use, seasonal range locations. Use LANDSAT satellite data to develop cover map for area. Develop computer model (PATREC) to predict loss of habitat potential to support big game, from mining disturbance and natural forest succession. Timing: December 1977 - June 1980. Expected to continue until 1983. Analysis Methods: Helicopter census, radio-telemetry, vegetation analysis. Satellite imagery techniques. Computer simulation modelling. Extensive statistical analysis.

Value to OIA Study: Conclusions: Big game summer, winter areas located and described, migration corridors located (some in OIA study area). Habitat and forage utilization described computer models for big game habitat evaluation developed. Untested models presented for prairie falcons, sandhill cranes, ruffed grouse. Baseline Data: Results will serve as important baseline for OIA Study. Further Study: Habitat quality model (PATREC) should be applied to OIA study area, to estimate potential habitat losses. Effects of human activity, especially illegal harvest, should be investigated.

Subjective Rating of Document: Comprehensive long-term study of phosphate mining impacts on big game. Considerable data collected and thoroughly analyzed. Study area adjacent to OIA study area.

Comment: Material described in more detail in Kuck and Merrill 1981, Kvale 1982, Kuck et al. 1982.

Kuck, L., C.T. Kvale, E.H. Merrill, and K. Woodruff. 1979. Cooperative wildlife phosphate study, progress report. Idaho Department of Fish and Game, Soda Springs. 308pp. (ANALYZED DATA)

Location: IDFG, Soda Springs, Idaho. Cooperative Wildlife-phosphate study area (950 mi², eastern Caribou County, northeastern Bear Lake County).

Evaluation: Design: Census mule deer, elk and moose. Document annual productivity. Determine seasonal distributions of big game. Develop cover map of area, using LANDSAT satellite data. Use radio-telemetry to determine movements distributions, migration routes, habitat use, and effects of mining disturbances on big game. Develop computer model to simulate effects of phosphate mining on big game populations. Surveys of two endangered raptors (Bald eagle, peregrine falcon). Material described in more detail in Kuck 1979 (Endangered raptors), Kuck and Merrill 1981, Kvale 1982, Kuck et al. 1982. Timing: December 1977 - December 1979, continuing to 1983. Analysis Methods: Helicopter census, radio-telemetry, vegetation analysis, LANDSAT satellite data analysis. Road survey of raptors, preliminary statistical analysis completed.

Value to OIA Study: Conclusions: LANDSAT data produced adequate vegetation mappings. Helicopter surveys, Radio-telemetry have produced good seasonal distributions, migration patterns (including northern Bear Lake County). Vegetation analysis of big game seasonal use areas. Intensive study of bald eagle feeding roosting sites. Baseline Data: Results should serve as important baseline for OIA study area. Further Study: Study will be continued until 1983.

Subjective Rating of Document: First phases of comprehensive, long-term study of phosphate mining impacts on big game. Important seasonal habitat information on endangered raptors.

Kuck, L. and Merrill, E.H. 1981. Federal Aid to Wildlife Restoration. S.E. Idaho Wildl. Studies. Big Game Movements and habitat use in Southeastern Idaho. Job Progress report. Project W-160-R-8. Idaho Department of Fish and Game. Soda Springs, Idaho. 171pp. (ANALYZED DATA)

Location: IDFG, Soda Springs, Idaho. Cooperative Wildlife-Phosphate Study area. (950 mi² in Caribou County, northern Bear Lake County). IDFG, Soda Springs.

Evaluation: Design: Determine mule deer, elk, and moose movements, and habitat use patterns within the phosphate mining area of southeast Idaho. Determine mule deer migration behavior, route, and ascertain potential mining barriers to migration. Radio-telemetry of 127 animals, 5334 radio relocations, track counts. Timing: Jan. 1977-June 1981. Analysis Methods: Chi², Bonferroni-Z tests of utilization: availability, Convex polygon minimum area.

Value to OIA Study: Conclusions: Major deer and elk winter and summer ranges were identified, a major one being on the Georgetown front in Bear Lake County. Three migration routes were located on Georgetown front. Habitat features (elevation, slope vegetation type, aspect) were evaluated for summer and winter ranges. Some intensively monitored deer were delayed in migration to winter ranges by mining activity. Additional material on computer implementation of habitat evaluation model (PATREC) described separately as Kuck 1981. Baseline Data: Data for northern Bear Lake County can serve as baseline for big-game information.

Subjective Rating of Document: Ranges and migration routes in Bear Lake County are directly applicable. Habitat use parameters are also valuable because of the nearness and applicability to Bear Lake County.

Kuck, L. and E.H. Merrill. 1981. Federal aid to wildlife restoration. Southeast Idaho Wildlife Studies. Big game movements and habitat use in southeastern Idaho. Job progress report. Project W-160-R-8. Idaho Department of Fish and Game, Soda Springs, Idaho. 171pp. (MAPPING)

Location: IDFG, Soda Springs

Contact Person: Lonn Kuck, Idaho Department of Fish and Game, Soda Springs.

Type of Map: Species Distribution

Area Covered: Georgetown Front (northern Bear Lake County), and Eastern Caribou County.

Scale: 1" = 6 miles

Evaluation: Species Included: Mule deer, elk, moose. Seasonal home ranges from radio-telemetry, mule deer migration routes, elk calving areas. Distribution From Field Studies. Year of Original Mapping: 1977-81. Number of Years of Data: 3.

Subjective Evaluation of Mapping System: Good evaluation of home areas, migration routes of a limited number of animals.

Kuck, L., E. Merrill, G. Hompland, and L. Evans. 1982. Federal aid to wildlife restoration. Southeast Idaho Wildlife Studies. Phosphate mining impacts on big game. Job progress report. Project W-160-R-9. Idaho Department of Fish and Game, Soda Springs. 355pp. (ANALYZED DATA)

Location: IDFG, Soda Springs, Idaho. Cooperative Wildlife-Phosphate study area (950 mi², north and east of Soda Springs, including north eastern Bear Lake County). IDFG, Soda Springs.

Evaluation: Design: Assess impacts of mining disturbance on mule deer and elk calves. Describe mule deer summer range. Determine effects of intensive disturbance on young elk calves. Radio telemetry of 10 mule deer on summer range, 13 elk calves (5 disturbed by human presence, 8 control). Describe summer range characteristics, evaluate impact of forest succession. Vegetation analysis. Mule deer summer range and elk calving areas described in terms of elevation, slope, aspect, vegetation class, land form. Timing: Spring-Summer 1981. Analysis Methods: Cluster analysis (dendrogram), Jaccard's Index of Association, coefficient of association, diversity index, Chi², Bonferroni-Z, T-test, Kolmogorov-Smirnov, Spearman R., Convex polygon home area method.

Value to OIA Study: Conclusions: Mule deer summer range appears very important in yearly cycle. Vegetation characteristics described, with suggestions for improving revegetation techniques. Disturbance of young elk calves caused important behavioral, social impacts which could lead to reduced survival. Baseline Data: Descriptions of mule deer summer range and elk calving areas, should apply to OIA study area, valuable information for reducing effects of exploration impacts. Further Study: Summer range, elk calving areas, should be surveyed in Bear Lake County.

Subjective Rating of Document: Intensive study of effects of mining disturbance on muledeer and elk. Important baseline for nearby Bear Lake County.

Comment: Summer range quality is now believed to be critical in preparing mule deer for winter. Because does return to the same area each year, and use a small summer area, its quality appears to be important. Effects of mining disturbance, as well as effects of natural forest succession, appear to be major factors in a possible decline of deer numbers. Mitigation of natural succession appears to be an important tool in improving big game numbers, and could be a viable tool for offsetting mine disturbances. Descriptions of preferred summer range can aid in revegetation. An additional section of report described elsewhere as Evans 1982.

Kuck, L., E.H. Merrill, G. Hompland, and L. Evans. 1982. Federal aid to wildlife restoration. Southeast Idaho Wildlife Studies. Phosphate mining impacts on big game. Job Progress report. Project W-160-R-9. Idaho Department of Fish and Game, Soda Springs, ID. 355pp. (MAPPING)

Location: Idaho Department of Fish and Game, Soda Springs, Idaho.

Contact Person: Lonn Kuck (Senior Wildlife Biologist).

Type of Map: Species Distribution

Area Covered: Cooperative Wildlife-Phosphate study area (includes northern Bear Lake County - Georgetown Front, Georgetown Canyon).

Scale: various, 1" = 1 to 6 miles.

Evaluation: Species Included: radio-telemetry locations of mule deer, elk, moose: summer, winter range; elk calving areas, deer migration routes. Year of Original Mapping: 1979. Years Updated: 1980. Number of Years of Data: 2.

Subjective Evaluation of Mapping System: Valuable mapping of big game in north Bear Lake County. Continued to present.

Kuck, L., E.H. Merrill, C.T. Kvale, and G. Hompland. 1982. Cooperative Wildlife-Phosphate Study. Progress Report, 1981. Idaho Department of Fish and Game, Soda Springs, Idaho. 625pp. (ANALYZED DATA)

Location: IDFG, Soda Springs, Idaho. Cooperative Wildlife-phosphate study area (950 mi², eastern Caribou County, northeastern Bear Lake County). IDFG, Soda Springs.

Evaluation: Design: Determine impact of phosphate mining disturbance on mule deer, elk, and moose. Determine summer and winter ranges, movements. Describe summer range vegetation. Computer model for habitat evaluation on seasonal big game ranges. Timing: December 1977 - July 1981, continuing to 1983. Analysis Methods: Helicopter census, radio-telemetry, vegetation analysis, simulated disturbance of elk calves. Complete statistical analysis.

Value to OIA Study: Conclusions: Big game summer, winter areas described, migration corridors located. Seasonal areas described vegetationally. Deer and elk disturbance by mining and human activities described. Computer model (PATREC) used to predict losses of potential big game through mining habitat disturbance and natural aspen succession. Baseline Data: Results will serve as important baseline for OIA study area. Further Study: Habitat quality evaluation model (PATREC) should be applied to OIA study area, to estimate potential habitat losses. Effects of human activity, especially illegal harvest, should be investigated.

Subjective Rating of Document: Comprehensive, long-term study of phosphate mining impacts on big game. Considerable data collected and thoroughly analyzed. Study area is adjacent to OIA study area.

Comment: This study area is immediately adjacent to, and covers part of, Bear Lake County. Most aspects of big-game habitats and movement patterns should be similar to OIA study area. Conclusions on mitigation of mule deer summer range loss through reversal of aspen stand succession can be applied directly. Material described in more detail in Kuck and Merrill 1981, Kuck et al. 1982, Kvale 1982, Merrill 1981.

Kvale, C.T. 1982. Federal aid to wildlife restoration. Southeast Idaho Wildlife Studies. Big game winter range habitat evaluation. Job progress report. Project W-160-R-8. Idaho Department of Fish and Game, Boise, Idaho. 216pp. (ANALYZED DATA)

Location: IDFG, Soda Springs, Idaho. Cooperative Wildlife-Phosphate Study area (950 mi² in Caribou County, northern Bear Lake County). IDFG, Soda Springs.

Evaluation: Design: Evaluate winter habitat of mule deer, elk, and moose by examination of vegetation types, succession, and forage utilization. Determine usefulness of LANDSAT vegetation mappings. LANDSAT satellite data, helicopter survey, permanent vegetation transects, exclosures, 116 big game feeding sites with 30,400 instances of use. Timing: Dec. 1977 - May 1981. Analysis Methods: Mapping of sightings on winter range, Chi², Bonferonni-Z test.

Value to OIA Study: Conclusions: LANDSAT data was adequate for mapping 17 vegetation types. Helicopter surveys of mule deer, elk, and moose on winter range, including Georgetown Front in Bear Lake County. Data on herd compositions, group size, and habitat parameters (elevation, slope, aspect, vegetation type). Evaluation of utilization of various feeds. Baseline Data: Good winter range sightings data for Georgetown Front (major wintering area). Vegetation transects and exclosure - Sulphur Canyon and Fossil Canyon. Further Study: Similar winter range surveys should be done in Bear Lake County.

Subjective Rating of Document: Good mapping of winter range on Georgetown Front. Vegetation use and forage utilization should be applicable. LANDSAT data methods should be applicable to vegetation mapping.

Kvale, C.T. 1982. Federal aid to wildlife restoration. Southeast Idaho Wildlife Studies. Big game winter range habitat evaluation. Job Progress Report. Report W-160-R-8. Idaho Department of Fish and Game, Boise, Idaho. 216pp. (MAPPING)

Location: IDFG, Soda Springs.

Contact Person: Lonn Kuck, Idaho Department of Fish and Game, Soda Springs, Idaho.

Type of Map: Species Distribution.

Area Covered: Georgetown Front (northern Bear Lake County) and eastern Caribou County.

Scale: 1" = 2 miles.

Evaluation: Species Included: Mule deer, elk, moose. Distribution from field studies. Year of Original Mapping: 1977. Years Updated: 78, 79, 80. Number of Years of Data. 3.

Subjective Evaluation of Mapping System: Results of 6 helicopter surveys of winter range. Sightings mapped, tabulated by quarter section. Excellent winter range map of area.

Kvale, C.T., and J.B. Wood. 1980. Federal aid to wildlife restoration. Idaho Range Study: Land Resource Inventory Demonstration Project. Final report. Project W-160-R. Idaho Department of Fish and Game, Boise, ID. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Soda Springs, Idaho.

Evaluation: Design: Use LANDSAT satellite data (multispectral imagery) to develop vegetation maps of Cooperative Wildlife-Phosphate study area (Caribou County). Digital data is converted to vegetation maps (color or digital), with 1.1 acre units, for use with topographic overlays. 14 vegetation types were discriminated. Computer programs were developed to decode satellite data, interpret and develop maps of any scale. Ground truthing was based on simple vegetation plots.

Timing: 1975-1977. Analysis Methods: No data presented.

Value to OIA Study: Conclusions: Methods were used to develop vegetation maps of study area. Method is only cost-effective means of mapping large areas. Demonstration package is included in results.

"Vegetation types" used are flexible, many possible combinations.

Many possible wildlife uses. Baseline Data: Vegetation maps suitable as baseline data for changes in land use, habitat loss. Further Study: Vegetation maps should be made for Bear Lake County.

Subjective Rating of Document: LANDSAT imagery provides cost-effective tool for developing vegetation maps of OIA study area. Some ground-truthing necessary.

Comment: See description of output maps cited elsewhere as: IDFG LANDSAT satellite vegetation maps, color and digital.

Lynott, B. 1974. On the adaptability of prairie grouse - A review. Unpublished report. Department of Biology, Idaho State University, Pocatello, ID. 47pp. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Pocatello, ID.

Evaluation: Design: Literature review of sharp-tailed grouse management problems in Idaho. Draws on published literature throughout West, also on prairie chickens. Timing: 1974. Analysis Methods: None.

Value to OIA Study: Conclusions: Sharp-tailed grouse are a valuable native game bird, but have been declining in Idaho since the 1950's. Problems stem from agricultural encroachment (large, "clean", farms,

little unfarmed area) and heavy grazing. They are, however, adaptable to some extent, apparently existing in small patches of uncultivated areas. Grainfields are used as winter food, and light grazing may be tolerated. Water is not a critical requirement. Seasonal movements may sometimes be extensive. Careful management should allow good numbers of this native resource.

Subjective Rating of Document: Valuable discussion of sharp-tailed grouse management problems, habitat requirements, and areas for further study on OIA study area. Specifically addresses Arbon and Curlew Valleys in Power and Oneida Counties.

McArdle, B.A. 1977. The effect of sagebrush reduction practices on sharp-tailed grouse use in southeastern Idaho. Thesis. Utah State University. Logan, UT. 72pp. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Habitat characteristics were determined where sharp-tailed grouse were observed. Numbers and seasonal distribution were compared under 3 range manipulation practices. Line-transect surveys were used to census grouse. Vegetation transects were used to determine habitat characteristics. Food habits analysis. Timing: May-August, 1974-1975. Analysis Methods: Line-transect survey of grouse numbers. χ^2 test between 3 treatments, control. Multiple regression analysis was used to determine significant vegetative influences among 6 major plant species. R^2 analysis.

Value to OIA Study: Conclusions: Sagebrush reduction enhanced sharp-tailed grouse use on Curlew National Grasslands, Oneida County, Idaho. Chaining created the most preferred habitat, burning and herbicide spraying were less effective. Manipulated access had lower canopy cover of shrubs, forbs, more of grasses. 20-40% shrub cover appeared optimum for spring and summer use, more in winter. Heavy livestock grazing and agricultural use were detrimental to grouse use. Baseline Data: No information on distribution in Bear Lake County, valuable indication of habitat requirements. Further Study: Recommends further study of winter habits, and on other methods of sagebrush manipulation.

Subjective Reading of Document: Valuable information on habitat requirements and means of enhancing sharp-tailed grouse habitat in Southern Idaho. Sharp-tail habitat should be similar on the OIA study area, so these results should be valuable for mitigation of impacts.

Merrill, E.H. 1981. Federal aid to wildlife restoration. S.E. Idaho Wildlife Studies. Mining impacts on big game distribution. Job Progress Report. Project W-160-R-8. Idaho Department of Fish and Game. Soda Springs, ID. 33pp. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Soda Springs.

Evaluation: Design: Establish intensity of use of deer, elk, and moose near active phosphate mine sites. Wooley Valley phosphate mine is used by big-game during winter. Maybe Canyon mine during summer months. Determine how effects of mining are influenced by adjacent vegetation types. Pellet group counts on 120 transects within 4 distance intervals, near active and inactive mining areas and a control area. Timing: 1979-80 winter, 1980 summer. Analysis Methods: Analysis-of-variance. Average pellets/plot.

Value to OIA Study: Conclusions: In most vegetation types, use by elk and moose was less in winter near active mine sites than in control areas. Use by elk and moose in summer was not different between mine and control sites. Baseline Data: Suitable as baseline data for predicting similar impacts of oil and gas exploration. Further Study: Recommended radio-telemetry of deer (specifically physiological-monitoring) to determine effects of mining disturbance.

Subjective Rating of Document: Results are directly applicable to Bear Lake County Oil and Gas Exploration, and are valuable for predicting impacts of similar practices.

Comments: During winter, elk were somewhat restricted to limited habitat (windswept ridges). In these limited areas, which happened to occur near mines, densities were higher than in control areas. Under these circumstances, elk appeared able to adapt to mining activities and disturbances. However, increased mining activities (with attendant noise, lights, human activity, equipment operation) may cause local displacement of big game. Greater impacts may result from increased recreational access and illegal harvest than from mining activities themselves.

Merrill, L. and R. Tews. 1971. Winter range use by mule deer in southeastern Idaho. Unpublished report. 17pp. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Observation of behavior on winter range (Georgetown Canyon, Bear Lake County). Observed use and preference of browse and forage on winter range. Daily counts, feeding observations, feeding site examinations. Timing: Jan - April 1971. Analysis Methods: not presented.

Value to OIA Study: Conclusions: Major forage and browse species were identified (wheatgrass, big sage, serviceberry; to lesser extent mountain mahogany, bitterbrush). Movements to lowest elevation were

precipitated by heavy snowstorms. Feeding was concentrated on tall shrubs or exposed grasses. Mountain mahogany was not consumed as much as expected. Baseline Data: Student study, minor values as baseline on area.

Subjective Rating of Document: Because of qualitative value of information, information on mule deer wintering habits is of limited value for baseline data on OIA study area.

Nielson, B.R. 1982. Federal aid in fish restoration. Bear Lake cutthroat trout enhancement program, 1981 annual performance report. Project F-26-R-6, Utah Division of Wildlife Resources, Salt Lake City, Utah. 41pp. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Gill nets were used to assess population trends of Bear Lake cutthroat trout in Bear Lake, Utah - Idaho. Native "Bear-Lake type" cutthroats were captured and eggs collected. Food habits, age composition, meristic characteristics were also analyzed. Timing: 1981. Seventh annual progress report. Analysis Methods: Data tabulated (total, means, percents, catch/time). Gill-netting data was analyzed using Analysis-of-Variance with date, depth, station.

Value to OIA Study: Conclusions: Bear Lake cutthroat are the only native trout in Bear Lake. Available population has been maintained historically. Natural recruitment has been severely impacted by human activities on the three spawning streams, especially by de-watering. 800,000 native cutthroat were raised and stocked in 1981, along with 16,000 rainbow and 184,000 lake trout. Results from 7 gill-netting stations, repeated annually since 1977 are given. 3,735 fish were captured in 1981 - 45% Utah sucker, 22% 2 species whitefish, 19% Bonneville Cisco, 11% cutthroat, 3% of 5 other species. Cutthroat capture rate per station was not significantly different. 2241 anglers were interviewed during creel census and 1213 fish examined (55% cutthroat, 11% rainbow, 11% lake trout, and 23% whitefish). Fishery is jointly managed by Utah and Idaho.

Subjective Rating of Document: Valuable study of Bear Lake cutthroat, an endemic sub-species. Data is very useful for management of this fishery. Well-designed long-term study of important fishery resource on OIA study area.

Norrel, D. 1982. Federal aid to wildlife restoration. Endangered and threatened species investigation; Peregrine falcon propagation. Job Progress Report. Project ID-ES-1. Idaho Department of Fish and Game, Boise, ID. 5pp. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Pocatello, ID.

Evaluation: Design: Establish breeding populations of peregrine falcons in Idaho. Goals are to establish adequate breeding facilities and breeding stock to release 90 young peregrines using hack box procedures, over the next 7 years. Facilities are located at Fort Collins, CO. Timing: August 1980 - June 1981. Analysis Methods: none.

Value to OIA Study: Conclusions: First releases in Idaho are scheduled for spring 1982. Baseline Data: not suitable.

Subjective Rating of Document: Limited value, points out importance of protecting suitable habitat for peregrine falcons in southeastern Idaho.

Norrel, R.C. 1982. Federal aid to wildlife restoration. Upland game surveys and inventories. Job progress report. Project W-170-R-5. Idaho Department of Fish and Game. Boise, ID. 220pp. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Data on 7 upland game birds: hunter bag checks, trend counts, brood counts, counts of males on strutting grounds. Region 5 report. Timing: April 1981 - March 1982. Analysis Methods: Data tabulated (totals, averages, % change).

Value to OIA Study: Conclusions: Data presented for sage grouse, mourning doves specifically for Bear Lake County, ruffed and blue grouse, hungarian partridge, Region-wide. Data very limited in quantity. Sage grouse were counted on 1 lek near Montpelier (1969-1981, mean of 53 males), 3 leks near Soda Springs. Baseline Data: Limited value as baseline. Further Study: Any additional amount of data collected would greatly improve value.

Subjective Rating of Document: Only harvest data available for upland game species on OIA area. Some value in assessing populations, harvest of upland game in Bear Lake County.

Nunan, R.L. 1972. Effect of Bear River storage on water quality in Bear Lake, Utah-Idaho. Thesis. Utah State University, Logan, Utah. 88pp. (ANALYZED DATA)

Location: Fisheries and Wildlife Department, Utah State University, Logan, Utah.

Evaluation: Design: Analyze nature and causes of changes in Bear Lake salinity values caused by use of lake as storage reservoir. Test hypothesis that lake water is being diluted by diversion of Bear River

waters into lake since 1912. Water chemistry samples from 6 stations were analyzed. A water-salt budget simulation model was used to analyze historical records. Chemical analyses were made according to standard methods. Timing: 1971. Analysis Methods: Analyses of variance, Newman-Keuls multiple mean comparison, data tabulated (means, range).

Value to OIA Study: Conclusions: Water chemistry data were obtained (calcium, magnesium, sulphate, potassium, chloride, carbonate, pH, temperature, conductivity). Concentration of each mineral has decreased 30-50% since 1912 - A water-salt model was constructed, based on annual inflow, outflow, and evaporation, which predicted mineral concentrations. Data upheld theory that salinity of the lake is being diluted. Prior to 1912, salinity was increasing due to greater evaporation than inflow. Baseline Data: Suitable for baseline data. Further Study: Water-salt budget model should be refined to include newer salinity, hydrology models.

Subjective Rating of Document: Valuable data on water chemistry of Bear Lake. Data might be used if further studies of Bear Lake are undertaken.

Nyquist, D. 1967. Eutrophication trends of Bear Lake. Idaho-Utah and their effect on the distribution and biological productivity of Zooplankton. Dissertation, Utah State University, Logan, Utah. (ANALYZED DATA)

Location: Utah State University Library, Logan, Utah.

Evaluation: Design: 23 species of zooplankton and 9 other species of flora and fauna were collected and 17 physical and chemical parameters were measured during sampling in Bear Lake to 1) Establish a record of current zooplankton population; 2) compile a qualitative and quantitative standard for future comparisons; 3) assess source and quantity of present nutrient load; 4) investigate effect of present nutrient additions on zooplankton productivity. Timing: 17 months 1964-1965. Analysis Methods: Correlation and regression analysis on relationships between chemical analysis and associated zooplankton and on 3 Lake Zones investigated. Water quality analyses.

Value to OIA Study: Conclusions: Defined various environmental requirements necessary for maintenance of individual species. Bacteriological testing of Bear Lake Waters revealed large percentage of littoral and limnetic zones presented problems with respect to public use and water quality. Baseline Data: Valuable data for studies of Bear Lake, lists of zooplankton species present, and measurements of chemical parameters of lake waters. Further Study: This paper should be used for background if studies of Bear Lake are undertaken.

Subjective Rating of Document: Valuable information on management of Bear Lake. Addresses some of the impacts on water quality of increasing human development.

Perk, J.M. 1979. Comments on Big Game/Access relationships. Presented at Wildlife Management Workshop, Colorado State University, January 1979. 20 pp. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello.

Oelklaus, W.F. III, 1976. Chukar partridge dispersion along the middle and lower Snake and Columbia Rivers. M.S. Thesis. University of Idaho, Moscow, Idaho. 56 pp. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: An audio census technique was developed for chukars, and used to study habitat use along lower Snake River, Idaho. Timing: 1974-1975. Analysis Methods: Data presented graphically (regression analysis, correlation).

Value to OIA Study: Conclusions: The audio census technique was successful for locating, estimating number of chukars, without visual contact. Taped "Rally calls" were played twice, and replies counted for 10 1-minute sampling periods. A regression equation was used to estimate flock size. Estimates were best if used when flocks were concentrated in late summer and fall, between 10 am and 3 pm. Human, avian predator, or coyote disturbance affected results. Only 6% of flocks were known not to respond. Habitat information may be similar to Bear Lake County (hot, dry talus or cliff areas along river). Some water is required. Considerable daily movements occur, making habitat studies difficult. Baseline Data: Not suitable. Further Study: Census techniques should be used to determine chukar numbers in Bear Lake County.

Subjective Rating of Document: Valuable census technique for chukars.

Method should be used to evaluate pre-development chukar populations on OIA study area.

Oldenburg, L. E., and M. Medford. 1982. Federal aid to wildlife restoration. Big game population status, trends, and utilization; associated habitat status: Elk. Job progress report. Project W-170-R-5. Idaho Department of Fish and Game, Boise. 248 pp. Location: Idaho Department of Fish and Game, Pocatello, Idaho. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Information on controlled elk hunt, population presented. Data from composition surveys, harvest records, telephone survey, aerial counts. Timing: July 1980 - June 1981. Analysis Methods: Data tabulated. Herd composition presented (Bull:Cow:calf).

Value to OIA Study: Population in Unit 76 (eastern Caribou, Bear Lake Counties) appears to be expanding. Elk were observed in areas outside of traditional wintering areas. Estimated base population 1000 elk, fall 1200. Bull:cow:calf ratios of 33:100:40 observed. Aerial census of 746 achieved by Kuck et al. in northern portion of Unit. 350 controlled hunt permits were issued (145 in Bear Lake County sub-unit). Hunter success was 38%, and 50 were harvested on Bear Lake sub-unit. Elk are believed to be approaching carrying capacity. Summary of harvest information 1972-1980 presented. Baseline Data: Best available data for Unit 76. Data is compiled each year.

Subjective Rating of Document: Best available data on elk harvest, population in Bear Lake County.

Oldenburg, L. E., and M. Medford. 1982. Federal aid to wildlife restoration. Big Game population status, trends, and utilization; associated habitat status: Moose. Job Progress report. Project W-17-R-5. Idaho Department of Fish and Game, Boise. 43 pp. (ANALYZED DATA)

Location: Idaho Department of Fish and Game, Pocatello.

Evaluation: Design: Information on controlled moose hunt, population presented. Data from composition surveys, harvest records, telephone survey. Timing: July 1980 - June 1981. Analysis Methods: Data tabulated. Herd compositions presented.

Value to OIA Study: Conclusions: Moose population in Unit 76 (eastern Caribou, Bear Lake Counties) appears to be increasing. Bull:Cow:Calf ratio of 313 moose classified appears indicative of continued good calf production. Estimated fall population of 500 animals. 29 moose were harvested in 1980. Summary of harvest information 1972-1980. Some information separated for Bear Lake County. Hunter success is high on Bear Lake sub-unit (60-100%). Baseline Data: Best available data for Unit 76. Data is compiled each year. Further Study: Effect of Illegal Harvest on moose population should be studied.

Subjective Rating of Document: Best available data on moose harvest in Bear Lake County.

Oldenburg, L. E., and M. Medford. 1982. Federal aid to wildlife restoration. Big game population status, trends, and utilization; associated habitat status: Mule Deer. Job Progress Report. Project W-170-R-5. Idaho Department of Fish and Game, Boise. 249 pp. (ANALYZED DATA).

Location: Idaho Department of fish and Game, Pocatello.

Evaluation: Design: Information on mule deer hunt, population size presented. Data from check stations, telephone survey, composition counts, harvest records, helicopter census. Timing: July 1980-June 1981. Analysis Methods: Data tabulated, percents. Herd composition presented (Buck:Doe:Fawn).

Value to OIA Study: Conclusions: Mule deer populations in Unit 76 (eastern Caribou, Bear Lake Counties) appear to be stationary, but increasing in southern section. This may result in creation of sub-unit for Bear Lake County. B:D:F ratios for 195 deer were 48:100:66. These deer were censused by Kuck on Phosphate Study Area, but mild winter did not allow large numbers to be seen. Estimated harvest was 2753 deer, based on telephone survey. Hunter success was 15-17%. Summary of harvest data 1972-1980 presented. Old browse transects on area are being modernized. Baseline Data: Best available date for Unit 76. Data compiled each year.

Peek, J.M. 1979. Comments on Big Game/Access relationships. Presented at Wildlife Management Workshop, Colorado State University, January 1979. 20 pp. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello.

Evaluation: Design: Literature review of effects of increased road access on big game. Timing: 1979. Analysis Methods: none.

Value to OIA Study: Conclusions: Access is believed to be the single most important factor in assessing impact of logging and other disturbances. Exploited populations are found to decline and to shift location to unroaded areas. This is not the case, however, in unexploited areas such as National Parks. Other physical factors resulting from road construction are seen as less important: physical barriers to movement, habitat loss, sedimentation of streams, road kills. Increased access allows increased harvest, both legal and illegal (less true of controlled harvests). Activity, such as logging, is not necessarily avoided by animals, but active roads are (likewise snowmobile trails, etc.). Closure of roads is seen as an important, although sometimes unpopular, solution. Baseline Data: No baseline data. Further Study: Effects of increased road access, especially on illegal harvest should be investigated. Road closure, seasonally and at end of exploration work, should be included in management plans. Methods of minimizing impacts, such as mass transit of employees to drill site should be considered.

Subjective Rating of Document: Valuable description of road access, an important problem on OIA study area. Road closures may be valuable for minimizing effects of exploration activities.

Perry, L. E. 1943. Biology and economic significance of the peaknose cisco of Bear Lake, Idaho and Utah. Ph.D. Dissertation. University of Michigan. 229 pp. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello, Idaho (excerpts only).

Evaluation: Design: During fishery survey of Bear Lake (1938-1941), data collected on life history of Bonneville (peaknose) cisco. 800 specimens were collected and measured. 1400 stomachs were analyzed for food habits. Studies of incubation rate, sex ratio. Timing: 1938-1941. Analysis Methods: Age and growth measurements (data tabulated, means, percent change based on environmental conditions). Food habits (totals).

Value to OIA Study: Conclusions: Ecology of cisco (valuable sport and forage fish) described, vertical and seasonal distributions, food habits. Spawning activities described. Valuable forage for larger fish. Data on water chemistry, plankton. Baseline Data: Suitable ecological information for baseline on cisco, water quality. Further Study: Introduction of Bonneville cisco as forage fish elsewhere in region recommended.

Subjective Rating of Document: Very extensive study of ecology of Bonneville cisco in Bear Lake. Valuable background data on other aspects of Bear Lake.

Pettinger, L. R., A. Farmer, and M. Schamberger. 1978. Quantitative wildlife habitat evaluation using high-altitude color infrared aerial photographs. Presented at Pecora IV Symposium. Application of remote sensing data to wildlife management. Sioux Falls, SD. 12 pp. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Habitat value for elk and sage grouse of two proposed phosphate strip mine sites was determined using habitat parameter measurements from high-altitude color infrared aerial photos. Habitat suitability was assessed using Habitat Evaluation Procedures (HEP). Habitat parameters are measured (some on ground, some on photos). Habitat Suitability Indices (HSI) were derived for various habitat features (canopy cover, distance to water, sight distance, average stand width, distance to road, etc.). Standard photo interpretation techniques were used. Resulting HSI's were combined into estimates of habitat suitability, for 4 habitat types. This is multiplied by area involved to estimate available habitat. Timing: 1976. Analysis Methods: Habitat suitability indices (0.0-1.0) for 6-10 parameters were used to calculate Habitat Units (HU) available. Means for many quadrats (3 acre).

Value to OIA Study: Conclusions: HEP was found to be a viable cost-effective approach to evaluating habitat suitability. Elk and sage grouse were used as test species (Caribou County, Idaho). Can be used to estimate current habitat quality and quantity, and also temporal changes. Data can be collected adequately from high-altitude photos. Addition of limited ground survey data improves resolution. Baseline Data: May be suitable as indication of densities of elk, sage grouse on study area. Further Study: Method should be applied to OIA study area, perhaps used for other species. Habitat suitability indices must be derived for each species.

Subjective Rating of Document: Valuable tool for assessing environmental impacts of oil and gas exploration of OIA study area. Results might be applicable directly, as work was 12 miles north of Bear Lake County.

Platts, W. S. and C. Rountree. 1972. Georgetown Creek aquatic environment study. File 2630-Habitat. 14 pp. (ANALYZED DATA).

Location: Montpelier District Office, Caribou National Forest, Montpelier, Idaho.

Evaluation: Design: Documents environmental conditions as baseline information. Evaluated effectiveness of previous rehabilitation measures. 10 stream habitat inventory station were selected (5 physical habitat transects at each site). Water chemistry samples were taken monthly at 8 stations (June 1970-January 1971). Timing: 1970-1972. Analysis Methods: Standard stream evaluation, water chemistry techniques. Data tabulated.

Value to OIA Study: Conclusions: Georgetown Creek supports a suppressed trout fishery due to extensive alteration from highway and railroad encroachment, sedimentation, and pollution from mine and milling activities. Results show that Georgetown Creek has rehabilitated itself considerably since disturbance. Stream is very fertile, but good fish habitat is lacking. Survey of fishery populations has been done elsewhere. Habitat has been improved somewhat by placement of riprapping, artificial pools, etc. Baseline Data: Transects were documented on aerial photos. Suitable as baseline data. Further Study: Surveys should be repeated at later date.

Subjective Rating of Document: Valuable information on stream quality, fishery habitat suitability. Potential habitat improvement methods.

Rubright, K. 1980. Federal aid to wildlife restoration. Southeast Idaho Wildlife Studies. Phosphate mining impacts on big game. Job Progress Report. Project W-160-R-7. Idaho Department of Fish and Game, Soda Springs, Idaho. 49 pp. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Soda Springs.

Evaluation: Design: Conduct systematic inventories to establish wildlife densities and distributions on specific mine sites (big game and upland game birds) 600 pellet-group plots stratified by vegetation type, 21 aerial surveys, 60 miles of King line-transect survey for flushing forest grouse. Two phosphate mines, Caribou County Idaho. (13 mi. N. of Bear Lake County, 25 mi. E. of Soda Springs). Timing: July 1978-August 1979 (summers). Analysis Methods: King line-transect analysis, (Distance to each bird seen is recorded, density estimates calculated, χ^2 availability vs. utilization.

Value to OIA Study: Conclusions: Densities presented for 3 big game species, 2 forest grouse (average $\#/\text{mi}^2$: mule deer-10.8, elk-6.5, moose-0.9, ruffed grouse-14.6, blue grouse-14.0). Forest grouse densities were believed low. Big game values broken down by vegetation type, slope, aspect. Baseline Data: Because of this study was made quite close to the Bear Lake County study area, animal densities may serve as baseline information for assessing impact on summer range. Further Study: Conduct similar surveys on areas of intensive exploration in Bear Lake County.

Subjective Rating of Document: Intensive study of small area. High applicability to Bear Lake County, valuable for predicting impacts of oil and gas exploration.

Schegel, M.W. 1982. Federal aid to wildlife restoration. Endangered species: Wolf Ecology. Job progress report. Project ID-ES-1. Idaho Department of Fish and Game, Boise, Idaho. 4 pp. (ANALYZED DATA).

Location: Idaho Department of fish and Game, Pocatello, Idaho.

Evaluation: Design: Examine historical distribution and abundance of wolves in Idaho. Evaluate current status. Identify potential recovery sites. Develop wolf management guidelines for recovery sites. Information was compiled from a variety of records, mostly sightings. Timing: April 1981 to March 1982. Analysis Methods: Data tabulated by date, location, observation method (percents).

Value to OIA Study: Conclusions: 397 wolf reports in Idaho was compiled (67% in Boise and Clearwater National Forests, None in Caribou N.F. 8% on Targhee N.F. just to north of Caribou N.F.) Yellowstone National Park and a wilderness area in central Idaho were identified as potential recovery sites by the Northern Rocky Mountain Wolf Recovery Team, USFWS. 327 records are since 1971, and records from the Challis and Payette N.F. are increasing. Wolf Recovery Team Management guidelines have been prepared. Baseline Data: No sightings on OIA study area. Further Study: Recommends surveys of recovery sites for actual recovery potential, site-specific management guidelines. Further Study: Recommends surveys of recovery sites for actual recovery potential, site-specific management guidelines.

Subjective Rating of Document: Indication of state, federal concern for wolves in Idaho. Less likely to be found on OIA study area.

Sommerville, K.G. 1975. Aquatic constraints study, Bear Lake Utah-Idaho. Prepared for Bear Lake Regional Commission, Fish Haven, Idaho. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Describe biological, physical and chemical components of Bear Lake system. Assess impacts of human activities. Make recommendation concerning future uses of shore zone. Water quality measurements taken at 26 shore sites. Timing: 1975. Analysis Methods: Water quality data presented graphically.

Value to OIA Study: Conclusions: Bear Lake is an important recreational and fishery resource. Water quality is declining since 1950's due to effluent from vacation homes. Literature reviews. Qualitative data presented on 10 native, 6 introduced fish. Lists of aquatic and near shore birds and mammals. Lists of aquatic plants, invertebrates. Some data on water quality, fisheries of North Eden, Indian Creeks. Data on physical, chemical properties of Lake. Changes in water quality since 1912 presented. Potential impacts on the lake of some uses evaluated.

Subjective Rating of Document: Valuable overview of management problems, recommended solutions for Bear Lake. Useful for assessing impacts of oil and gas exploration in area.

Stauffer, D.F. and S.R. Peterson. 1982. (Draft) Seasonal habitat relationships of blue and ruffed grouse in Southeastern Idaho. University of Idaho, Moscow, Idaho. 91 pp. + appendices. (ANALYZED DATA).

Location: Soda Springs Resource Area, Headquarters Bureau of Land Management, Soda Springs, Idaho.

Evaluation: Design: Evaluates seasonal ruffed and blue grouse densities in a variety of habitat types. Assess vegetation structure and composition of grouse areas. Evaluates micro- and macro-habitat differences. Evaluates means of modifying vegetation to enhance grouse populations. Assesses effects of timber removal and grazing on grouse populations. 23 0.6-mile line transects were used to assess vegetation community structure. Vegetation was analyzed using the point-quarter method for trees and shrubs on transects. When grouse were observed, vegetation and structure were assessed on circular plots (numerous vegetation and structure parameters). Timing: 1979-1982. Analysis Methods: Vegetation densities were tabulated (means, standard deviations, coefficient of variation). Differences between season, vegetation types were tested using paired-T, χ^2 , Wilcoxon ranked-sums tests. Analysis of variance was used to test differences in grouse densities between vegetation types. Principal components analysis was used to generate gradients which describe habitat selection.

Value to OIA Study: Conclusions: Detailed results on ruffed and blue grouse habitat selection (Montpelier district, USFS, western Bear Lake Co.) were obtained, by season, nesting and breeding periods. Ruffed grouse, in general, used aspen and conifer types, while blue grouse used mountain mahogany and conifer types, while blue grouse used mountain mahogany and conifer types. A key to habitat suitability was prepared, which could be used to assess seasonal potential use by the 2 species. Recommendations were made for enhancing habitat through selective timber removal. Grazing, however, would reduce numbers through reduced nesting success. Baseline Data: Valuable baseline data on qualitative population estimates, detailed micro- and macro-habitat information.

Subjective Rating of Document: Very valuable description of ruffed and blue grouse habitat selection in Bear Lake County. Should be used to assess effects of impacts.

Comment: Also published as Stauffer, D.F. 1983. Ph.D. Dissertation, University of Idaho, Moscow.

U.S. Fish and Wildlife Service. 1979. Concept plan for preservation of redhead breeding habitat in the Great Basin. U.S. Fish and Wildlife Service, Portland, Oregon. 107 pp. (ANALYZED DATA).

Location: Bear Lake National Wildlife Refuge, U.S.F.W.S., Montpelier, Idaho.

Evaluation: Proposed to preserve 226,000 acres of privately-owned redhead production habitat in Utah, Nevada, Idaho, Oregon, Wyoming. 10,000 acres in Idaho in 14 areas. Areas were chosen on basis of value to redheads, value to other waterfowl and endangered species, habitat values, threats to the habitat. Timing: 1979. Analysis Methods: None.

Value to OIA Study: Conclusions: Lowering of water levels for irrigation purposes has impacted redhead production (specific nesting requirements: emergent vegetation of marshes and potholes, with hardstem bulrush and cattails). 8000 redheads breed in southeastern Idaho. Redhead populations have been erratic nationally and not always large enough to support a harvest. Population trends appear to be downward throughout the Great Basin. Protection of habitat may also enhance populations of bald eagles, whooping cranes, and peregrine falcons, as well as other waterfowl and non-game species. Most redheads in Idaho breed in the Bear Lake Valley, where agricultural practices may severely impact breeding success. It is recommended to acquire control of 2100 acres (31 separate wetlands) in upper Bear Lake Valley (Bear Lake County). This area is ranked first in importance of 14 areas surveyed in Idaho.

U.S. Fish and Wildlife Service. 1981. Environmental Impact Statement for preservation of Redhead waterfowl production wetlands, Southeast Idaho. Portland, Oregon, 107 pp. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Proposes to preserve 8000 acres of the best wetlands in Southeast Idaho, through purchase or easements. Timing: 1979-1981. Analysis Methods: none given.

Value to OIA Study: Conclusions: Wetlands described are important nesting sites for redhead ducks and many other species. 436,000 areas of wetlands have already been drained in Idaho. Present threats are from draining wetlands, diversion of water to agricultural uses, and grazing of vegetation necessary for nest concealment. Redhead populations are presently the lowest of major waterfowl species. During the 1970's only 4000 pairs were estimated in southeast Idaho. In Bear Lake County, 29 sites comprising 2199 acres have been identified as worthy of protection (1 acre upland for nesting with every 2.5 acres of wetlands). Exact locations are listed in Appendix. Redheads prefer a fairly distinct habitat type for nesting - emergent vegetation of marshes. Nests are often built in bulrushes or cattails, over 1 foot of water. A good mixture of patches of emergent vegetation and deeper open water is desirable. Areas would probably

actually benefit 5 times as many other waterfowl, as well as redheads. Redheads arrive in April, nest in May and June. Area is important staging site for redheads before fall migration. Nesting can be disturbed or disrupted by lowering of water levels, and grazing of vegetation.

Subjective Rating of Document: Valuable documentation of waterfowl, especially redhead duck, nesting habitat on private lands on OIA study area.

U.S. Forest Service. 1977. Environmental Analysis Report - Oil and Gas Leases. Caribou National Forest. 13 pp. (ANALYZED DATA).

Location: Soda Springs District Office, Caribou National Forest, Soda Springs, Idaho.

Evaluation: Design: Evaluate social, economic, and environmental factors for oil and gas leases on Caribou Forests. Timing: 1977. Analysis Methods: none.

Value to OIA Study: Conclusions: Oil and gas activities will be coordinated to minimize conflicts with existing land uses. Special conditions will be imposed where critical wildlife and fish habitat is known to exist. Examples - Big game winter range (Dec. 1 to Apr. 15), Big game calving and fawning areas moose and elk wallows (Sep. 1 to Nov. 1), Nest sites of threatened or endangered raptors (Mar. 1 to Aug. 1), Upland Grouse strutting grounds (Mar. 15 to Jul. 15). Degradation of water quality through siltation or spillage of drilling muds, etc. will be avoided. Roads may be closed to restrict access. Baseline Data: Brief qualitative description of wildlife and fisheries on area. Area includes northern Bear Lake County. Further Study: Recommends locating critical wildlife areas which are on leases. Little value as baseline due to qualitative nature of fish and wildlife information.

Subjective Rating of Document: Description of problems associated with oil and gas exploration.

U.S. Forest Service. 1981. Environmental assessment. Geothermal leasing on Caribou National Forest. Caribou National Forest, Pocatello, Idaho, 90 pp. (ANALYZED DATA).

Location: Soda Springs District Office, Caribou National Forest, Soda Springs, Idaho.

Evaluation: Design: Environmental assessment of geothermal exploration. Fishery and wildlife values are briefly summarized, along with description of other areas which may warrant special consideration. Timing: 1981. Analysis Methods: None.

Value to OIA Study: Conclusions: Direct exploration activities (test hole drilling, building of access roads) will require additional assessment. Critical wildlife areas (big game winter range, elk calving areas, game bird critical areas, etc.) will be protected by restricting seasonal access. Impacts to fishery resources (spillage of drilling fluids, spillage of hot water into streams, siltation caused by road construction) could be important. Wildlife species and their critical areas are briefly described, although a map is provided. Two other areas in Bear Lake County are identified as being sensitive: the fishery resource at Montpelier Reservoir, and the large, high-elevation marsh at Elk Valley. In addition to big game, upland game birds, and threatened and endangered species mentioned elsewhere, "Sensitive" species are listed as believed to occur on the forest: Bobcat, ferruginous hawk, prairie falcon, sharp-tailed grouse, and river otter. Baseline Data: Qualitative description of wildlife is of limited value as baseline information. Further Study: Further assessment will be required before actual exploration activity occurs.

Subjective Rating of Document: Limited value for description of wildlife on Montpelier District (Bear Lake County). Does assess impacts of exploration, similar to oil and gas exploration.

U.S. Forest Service. 1981. Environmental assessment. Geothermal leasing on Caribou National Forest. Map-Critical habitat for wildlife. (MAPPING).

Location: Soda Springs District Office, Caribou National Forest, Soda Springs, Idaho.

Contact Person: Marilyn Hemker (Wildlife Biologist).

Type of Map: Habitat.

Scale: 1" = 4 miles.

Evaluation: Habitat Types Mapped: Big game winter range, elk calving areas, waterfowl and cranes summer habitat, grouse critical area.

Resolution: 1/2 mile diameter. Ground Truthed: Unknown.

Subjective Evaluation of Mapping System: Some value as indication of wildlife critical areas on Caribou National Forest.

Comments: Source believed to be Idaho Department of Fish and Game.

U.S. Forest Service. 1981. Action plan for temporary management of the Bonneville Cutthroat Trout (1981-1986). File 2620-Planning: Utah Cutthroat-Giraffe Creek. 3 pp.

Location: Montpelier District Office, Caribou National Forest, Montpelier, Idaho.

Evaluation: Design: Stream geomorphology stations on Giraffe Creek,

Dry Creek, and Preuss Creek will be read biannually, and additional stations established. Vegetation studies will be continued. Beaver habitat and populations will be surveyed in 1982. Beaver dam washouts will be monitored. Timing: 1981. Analysis Methods: none.

Value to OIA Study: Conclusions: Fishery and habitat will be maintained at 1980 level. Beaver activity, livestock use will be monitored.

Habitat will be improved by stream stabilization, beaver harvest.

Baseline Data: Stream habitat information suitable as baseline from which to monitor changes in quality of fishery.

Subjective Rating of Document: Indication of management concern, problems with potentially threatened Bonneville cutthroat in Bear Lake County. Stream habitat should be monitored and protected.

U.S. Forest Service. Aerial Photos. (MAPPING).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Contact Person: Bill Davidson (Regional Wildlife Manager).

Type of Map: Aerial photos.

Aerial Photos: Scale: 1:15,840. Date: 1963. Type: B&W.

U.S. Forest Service. 1981. Caribou National Forest Travel Plan. (MAPPING).

Location: Montpelier District Office, Caribou National Forest, Montpelier, Idaho.

Contact Person: Ronald M. Walters (Wildlife Biologist).

Type of Map: Habitat.

Area Covered: Caribou National Forest (includes Bear Lake County).

Scale: 1" = 2.5 miles.

Evaluation: Habitat Types Mapped: Restrictions on vehicle access, Bear Lake County area--most of area has restrictions on vehicle access.

All motor vehicles restricted to designated roadways. Some areas open to snowmobiling off roadway. Resolution: Diameter - 1/2 mile.

Subjective Evaluation of Mapping System: Indication of concern by

U.S.F.S. about disturbance to wildlife, impacts to meadows and stream quality by increased or unrestricted vehicle access.

U.S. Forest Service. Color Aerial Photos. (MAPPING).

Location: Montpelier District Office, Caribou National Forest, Montpelier, Idaho.

Contact Person: Ronald M. Walters (Wildlife Biologist).

Type of Map: Aerial Photos

Area Covered: Montpelier District, Caribou National Forest (includes Bear Lake County).

Aerial Photos: Scale: 4" = 1 mile. Date July 24, 1978. Type: Color.

Comments: Similar photos 1963. Black and White.

U.S. Forest Service. File 2620-Planning. Beaver Managment. Maps of beaver colonies, habitat suitability. (MAPPING).

Location: Montpelier District Office, Caribou National Forest, Montpelier, Idaho.

Contact Person: Ronald M. Walters (Wildlife Biologist).

Type of Map: Habitat and Species distribution.

Area Covered: Montpelier District (includes Bear Lake County).

Evaluation: Habitat Types Mapped: Suitability of habitat for beaver (rated excellent, good, questionable, unsuitable). Resolution:

Broken into stream segments to 0.1 miles. Ground Truthed?: Yes.

Number of seasons: 2.

Evaluation: Species Included: Beaver colonies. Year of Original mapping: '65 & '68.

Subjective Evaluation of Mapping system: Valuable data on habitat suitability, location of beaver colonies on OIA study area. Should be considered in assessing impacts of oil and gas exploration on Forest Service lands.

U.S. Forest Service. File 2620-Planning. Beaver Management. (RAW DATA).

Location: Montpelier District Office, Caribou National, Montpelier, Idaho.

Contact Person: Ronald M. Walters (Wildlife Biologist).

Evaluation: Design: Evaluation of habitat suitability for beaver on Montpelier District (includes Bear Lake County). Maps of stream survey results, beaver colonies. Management recommendations for beaver management. Trend counts on Montpelier Creek. Habitat suitability based on stream flow, gradient, food availability, other land uses. Timing: Stream surveys 1965, 1968. Correspondence, management plan. Anticipated Completion Date: Ongoing.

Value to OIA Study: Geographic Area Covered: Bear Lake County: Montpelier, Snowslide, Twin Springs, Preuss, Muddy, Dry, Giraffe, Whiskey, Georgetown Creeks. Baseline Date: Valuable baseline data, survey could be repeated. Further Study: Survey should be repeated to assess current condition. Potential for Use in Wildlife Management: Valuable data, technique for assessing beaver use. Has impact on fisheries, other wildlife.

Subjective Rating of Document: Valuable information on beaver numbers, habitat suitability on OIA study area.

U.S. Forest Service. 1970. File 2620-Planning. Beaver Management. Beaver biological management plan, Montpelier Ranger District. (ANALYZED DATA).

Location: Montpelier District Office. Caribou National Forest, Montpelier, Idaho.

Evaluation: Design: Management plan for beaver on Montpelier Ranger District (includes Bear Lake County). Streams surveyed. Food availability, habitat suitability rated. Number of acres of suitable habitat estimated. Number of colonies counted, population estimated (6 beaver/colony). Carrying capacity on suitable acres determined. Timing: Surveys 1965 and 1968. Analysis Methods: Data tabulated (Acres of habitat, number of colonies, carrying capacity).

Value to OIA Study: Conclusions: 22 streams surveyed (130 miles, 172 colonies located). Many areas are above carrying capacity and have depleted food supply. Beaver have value as furbearers and also contribute to watershed, fish and wildlife, recreation, and esthetics. But their presence can also damage these same values. Goal: manage on sustained yield basis, but remove beavers where conflicts occur (irrigation ditches, etc.). Possible improvements include: Rest-rotation grazing-protects willow and aspen from livestock over-use, Timber sales-protect aspen from physical damage, road construction-not done in drainage bottoms to protect beaver habitat. Baseline Data: Valuable baseline survey of beaver habitat numbers in Bear Lake County. Further Study: Surveys of food availability, habitat condition. Should be surveyed annually.

Subjective Rating of Document: Valuable information on management problems and concerns with beaver on OIA study area. Valuable baseline information for Bear Lake County.

U.S. Forest Service. File 2620-Planning. Big game winter range studies. (RAW DATA).

Location: Montpelier District Office, Caribou National Forest, Montpelier, Idaho.

Contact Person: Ronald M. Walters (Wildlife Biologist).

Evaluation: Design: Summary of browse transects on Montpelier District. Occasional range surveys-range condition, winter mortality. Browse transects include (not all at each site): Utilization of bitterbrush, serviceberry, pellet-group transects, Parker "3-step" and browse intercept transects, wildlife exposure. Summary of browse transect results, winter range improvement projects. Timing: 1974-1982. Some transects read annually since 1956. Anticipated Completion Date: Ongoing.

Value to OIA Study: Geographic Area Covered: Montpelier District, Caribou National Forest (includes Bear Lake County). Herd Unit #76-Georgetown Canyon, Home Canyon, Geneva Summit. Baseline Data: Browse transects data are collected in same way each year. Range surveys not repeatable. Further Study: Data will continue to be collected. Potential for Use in Wildlife Management: Important big game winter range. Browse transect offer information on range condition, but some methods are now outmoded. Transects offer too limited picture of overall winter range condition.

Subjective Rating of Document: Limited value as indication of big game winter range condition on OIA study area.

U.S. Forest Service. File 2620-Planning. Browse Utilization Studies-Honey area, Home Canyon. (RAW DATA).

Location: Montpelier District Office, Caribou National Forest, Montpelier, Idaho.

Contact Person: Ronald M. Walters (Wildlife Biologist).

Evaluation: Design: Big game winter range browse transects. Percent utilization bitterbrush serviceberry. Deer-days/acre (pellet group transects). Timing: Home Canyon (1954-1972), Honeycomb area (1958-1974). Anticipated Completion Date: Completed.

Value to OIA Study: Geographic Area Covered: Montpelier District Caribou National Forest (includes Bear Lake County). Home Canyon, Honeycomb areas. Baseline Data: Data collection repeated in same way each year. Further Study: More modern techniques could be used to re-establish transects. Potential for Use in Wildlife Management: Important deer winter range. Browse transects offer information on range condition, but methods are now outmoded. Transects cover too small area of winter range, offer only limited view.

Subjective Rating of Document: Limited value as indication of big game winter range condition on OIA study area.

U.S. Forest Service. File 2620-Planning. Deer herd Unit #76: Biological unit management plan. (RAW DATA).

Location: Montpelier District Office, Caribou National Forest, Montpelier, Idaho.

Contact Person: Ronald M. Walters (Wildlife Biologist).

Evaluation: Design: Various data on deer management on Montpelier District, Caribou National Forest. Harvest data, browse transect results (6 areas, some since 1955), long-term trend studies, ground and aerial surveys, vegetation photo surveys. Aerial observations often included other wildlife species (since 1967). Much of the information is from IDFG. Timing: 1955-1980. Anticipated Completion Date: Ongoing.

Value to OIA Study: Geographic Area Covered: Montpelier District, Caribou National Forest (includes Bear Lake County). Baseline Data: Browse transects, aerial surveys may be repeatable. Further Study: Data will continue to be collected. Potential for Use in Wildlife Management: Various data have some value as indications of herd size, range condition. Data not analyzed. Aerial surveys may offer valuable information on other wildlife. Browse transects offer only limited view of winter big game picture.

Subjective Rating of Document: Limited value as data on big game herds, Bear Lake County.

U.S. Forest Service. File 2620-Planning. Elk herd unit #76: Biological unit management plan. (RAW DATA).

Location: Montpelier District Office, Caribou National forest, Montpelier, Idaho.

Contact Person: Ronald M. Walters (Wildlife Biologist).

Evaluation: Design: Various data on elk management on Montpelier District, Caribou National Forest. Harvest data, browse transect results (3 areas, some since 1960), long-term trend studies, ground and aerial surveys, vegetation photo surveys. Aerial observations often included other wildlife species (since 1967). Much of information is from IDFG. Timing: 1955-1980. Anticipated Completion Date: Ongoing.

Value to OIA Study: Geographic Area Covered: Montpelier District, Caribou National Forest (includes Bear Lake County). Baseline Data: Browse transects, aerial surveys may be repeatable. Further Study: Data will continue to be collected. Potential for Use in Wildlife Management: Various data have some value as indications of herd size, range condition. Data not analyzed. Browse transects offer only limited view of wintering big game picture.

Subjective Rating of Document: Limited value as data on big game herds, Bear Lake County.

U.S. Forest Service. File 2620-Planning. Elk winter range surveys-Geneva Summit. (RAW DATA).

Location: Montpelier District Office, Caribou National Forest, Montpelier, Idaho. Contact Person: Ronald M. Walters (Wildlife Biologist).

Evaluation: Design: Elk winter range was evaluated. Several browse species were planted (1969). Survival was monitored (1969-1971). Timing: 1969-1971. Anticipated Completion Date: Completed.

Value to OIA Study: Geographic Area Covered: Geneva Summit (Bear Lake County). Baseline Data: Survival of seedlings may serve as baseline data. Further Study: Methods of improving winter range should be studied further. Potential for Use in Wildlife Management: Some potential as winter range improvement technique. Area is important elk winter range. Seedling survival has not, however, been good on test area.

Subjective Rating of Document: Some value as indication of big game winter range improvement technique on OIA study area.

U.S. Forest Service. Files 2620, 2630: Wildlife Studies. Soda Front Winter Range Studies (RAW DATA).

Location: Soda Spring District Office, Caribou National Forest, Soda Springs, Idaho. Contact Person: Marilyn Hemker (Wildlife Biologist).

Evaluation: Design: Big Game Winter Range Browse Improvement Project - Antelope Bitterbrush was planted in different locations 1972, 1978, 1979, 1980. Aerial Seeding Project - sagebrush, etc. was seeded. Browse utilization transects, 1959 through 1978. Parker 3-step trend survey. Big game exclosures, 1962-1970. Timing 1959 to present. Anticipated Completion Date: continuing.

Value to OIA Study: Geographic Area Covered: Sulphur Canyon, Soda Front, Swan Lake (just north of Bear Lake County border). Baseline Data: Most information repeated each year. Potential for Use in Wildlife Management: Some value as baseline vegetation information on areas near OIA study area, indication of probable success of revegetation efforts.

Subjective Rating of Document: Some value as indicator of long-term big game use and probable success of revegetation on study area.

U.S. Forest Service. Files 2620. Wildlife Studies. Winter Range trend studies. (RAW DATA).

Location: Soda Springs District Office, Caribou National Forest, Soda Springs, Idaho.

Contact Person: Marilyn Hemker (Wildlife Biologist).

Evaluation: Design: Deer winter range habitat trend transects were established in 1981-Vegetation trend is measured using line-intercept method. Maps and aerial photos as well as vegetation photos of site included. Timing: 1981. Anticipated Completion Date: Ongoing.

Value to OIA Study: Geographic Area Covered: Sulphur Canyon, Swan Lake (Soda Springs District, Caribou County). Baseline Data: Will be repeated every 5 years. Potential for Use in Wildlife Management: Provide potential for long-term assessment of big game habitat trends, method judged better than old Parker 3-step method.

Subjective Rating of Document: Data will be useful (near OIA study area) for assessing big game use trends.

U.S. Forest Service. File 2630. Diamond Creek Willow Burn. (RAW DATA).

Location: Soda Springs District Office. Caribou National Forest.

Contact Person: Marilyn Hemker (Wildlife Biologist).

Evaluation: Design: Increase moose habitat quantity and quality by selectively burning 90 acres of decadent willow stands, to promote resprouting. Includes environmental assessment. Timing: 1978-1980. Anticipated Completion Date: None.

Value to OIA Study: Geographic Area Covered: Diamond Creek, Caribou county (just north of OIA study area). Further Study: area monitored each year. Potential for Use in Wildlife Management: Example of potential ways to improve big game habitat, perhaps in mitigation of other impacts.

Subjective Rating of Document: Some value in mitigating impacts of exploration, due to nearness to study area.

Other Comments: Forest Hydrologist has suggested that increased nutrients in runoff should not be permitted to contaminate the watershed. Hand cutting of willows may be a better option.

U.S. Forest Service. File 2630 - Habitat. Bitterbrush plantings - Georgetown Canyon deer range, lower Montpelier Canyon. (RAW DATA).

Location: Montpelier District Office, Caribou National Forest, Montpelier, Idaho.

Contact Person: Ronald M. Walters (Wildlife Biologist).

Evaluation: Design: 21,000 bitterbrush seedlings were planted in Montpelier Canyon (1976). 1000 planted at Georgetown Canyon on (1972), 13,000 (1974). Timing: 1976. Anticipated Completion Date: Completed.

Value to OIA Study: Geographic Area Covered: Montpelier District (includes Bear Lake County). Mouth of Montpelier Canyon. Baseline Data: Not Suitable. Further Study: Methods of improving winter range should be studied further. Survival of seedlings should be evaluated. Potential for Use in Wildlife Management: Some potential as winter range improvement technique. Area is important elk winter range.

Subjective Rating of Document: Some value as indication of big game winter range improvement technique on OIA study area.

U.S. Forest Service. Files 2630. Management of wildlife habitat. Herd Unit 76. Habitat improvement. (RAW DATA).

Location: Soda Springs District Office, Caribou National Forest, Soda Springs, Idaho. Contact Person: Marilyn Hemker (Wildlife Biologist).

Evaluation: Design: Improve quantity and quality of wildlife forage by removing old decadant trees and regenerating aspen, chokecherry, willow, serviceberry, etc. Areas to be treated include important year-round habitat for moose, critical spring, fall, and wintering areas for elk, and intermittent ranges for deer. Includes Environmental Assessment. Burned 200 acres in Dry Valley in 1977. Plans for seven more burns, 4 in Bear Lake county. Follow-up pellet group and browse utilization transects. Timing: 1977-present.

Value to OIA Study: Geographic Area Covered: Cloverknoll, Beaver Creek, Red Mountain, Nelson Canyon in Bear Lake County (Montpelier District), Dry Valley etc. in Soda Springs District. Further Study: Burning should be done on remaining areas and big game use and vegetation trend monitored afterwards. Potential for Use in Wildlife Management: Prescribed burns appear to have a very large potential for improving decadant aspen stands for big game and other wildlife use.

Subjective Rating of Document: Valuable example for improving wildlife habitat in OIA study area.

U.S. Forest Service. Files 2670: Threatened and Endangered Species. (RAW DATA).

Location: Soda Springs District Office, Caribou National Forest, Soda Springs, Idaho.

Contact Person: Marilyn Hemker (Wildlife Biologist).

Evaluation: Design: Information on Bald eagles on District. Includes Midwinter eagle counts-1982 (southeastern Idaho), Description of active bald eagle nest near Thayne, WY (1982), Proposed bald eagle nesting habitat in that area, with aerial photos (1978), correspondence on same. Timing: 1982.

Value to OIA Study: Geographic Area Covered: Soda Springs District, Caribou N.F. (Caribou and Bonneville Counties, part of Lincoln County, WY). Further Study: Nest will be monitored, disturbance in area controlled. Potential for Use in Wildlife Management: Similar management action should be undertaken if bald eagle nest located elsewhere.

Subjective Rating of Document: Some value to OIA area.

U.S. Forest Service. Files 5150 - Fuel Management. Prescribed burns: Clover Knoll area, Snowdrift Mountain. (RAW DATA).

Location: Montpelier District Office, Caribou National Forest, Montpelier, Idaho.

Contact Person: Ronald M. Walters (Wildlife Biologist).

Evaluation: Design: Objectives: Reduce aspen overstory density to produce dense aspen suckering. Reduce conifer cover 80%. Improve range quality for big game and other wildlife species by increasing desirable and intermediate plant species increasing diversity. Approximately 1600 acres were burned in 5 prescribed burns 1976-1981. Some areas also sprayed with herbicide. Timing: 1976-1981. Anticipated Completion Date: Ongoing.

Value to OIA Study: Geographic Area Covered: Montpelier District, Caribou National Forest (Bear Lake County) Snowdrift Mountain, Clover Knoll, Beaver Creek, Nelson Canyon. Baseline Data: Not suitable. Further Study: Possibility of increasing number of burns should be considered. Potential for Use in Wildlife Management: Valuable technique for improving wildlife habitat. Aspen degeneration and conifer invasion had reduced value of area as wildlife habitat. Increasing stand age had reduced amounts of young aspen, willow, serviceberry, chokecherry desirable forbs.

Subjective Rating of Document: Valuable wildlife habitat improvement technique for OIA study area. Possible means of off-site compensation for oil and gas impacts.

Comment: Successful burns: Snowslide Canyon - 370 acres, May 1976.
Clover Knoll, Giraffe Creek - 660 acres, Fall 1979, 1980. Manning
Creek - 250 acres, Sept. 1981. Snowdrift Mountain - 320 acres, Sept.
1981.

U.S. Forest Service. Files 2630. Wildlife Habitat. Bonneville Cutthroat
habitat and population studies. (ANALYZED DATA).

Location: Soda Springs District Office, Caribou National Forest, Soda
Springs, Idaho.

Evaluation: Design: Progress report (April 1982) on Bonneville
Cutthroat Action Plan. Five permanent stream survey transects were
established and read inside and outside of two livestock exclosures,
established in 1979 and 1981, one each on Giraffe Creek and Preuss
Creek, and a fifth transect on Upper Preuss Creek. Geomorphology and
bank sloughing measurements were made. Fish were sampled by
electro-shocking, and population estimates made for Giraffe Creek and
two areas on Preuss Creek. Length information was collected for aging
fish. Baseline Data: Bonneville Cutthroat populations are described
in Preuss Creek, Giraffe Creek, and Dry Creek drainages. Further
Study: Stream surveys will be made every second year. Populations
will continue to be monitored.

Subjective Rating of Document: Valuable information on location,
populations of potentially threatened Bonneville Cutthroat Trout on
OIA study area.

U.S. Forest Service. File 5150 - Fuel Management. Prescribed burn:
Montpelier Creek sage grouse habitat. (RAW DATA).

Location: Montpelier District Office, Caribou National Forest,
Montpelier, Idaho.

Contact Person: Ronald M. Walters (Wildlife Biologist).

Evaluation: Design: Burn 50 - 200 acres to convert small
sagebrush-dominated draws to earlier stages of plant succession. An
increase in habitat diversity and forbs favorable to sage grouse
should result. Burn was done before sage grouse nesting (begins May
15). Maps of site given. Timing: May 1980.

Anticipated Completion Date: Completed.

Value to OIA Study: Geographic Area Covered: Montpelier Creek,
Montpelier District, Caribou National Forest (Bear Lake County).

Baseline Data: Not suitable. Further Study: Success of burn should
be monitored. Burns of other areas should be considered. Potential
for Use in Wildlife Management: Valuable tool for sage grouse
habitat.

Subjective Rating of Document: Valuable tool for improvement of
sage grouse habitat on OIA study area. Should be considered as
off-site compensation for habitat lost due to oil and gas
exploration.

U.S. Forest Service. File 5150 - Fuel management. Prescribed burn: Montpelier Face and Worm creek. Prescribed burn areas. (RAW DATA).

Location: Montpelier District Office, Caribou National Forest, Montpelier, Idaho.

Contact Person: Ronald M. Walters (Wildlife Biologist).

Evaluation: Design: Environmental assessment, 245 acres burned. Reduce amount of big sagebrush. Result will be reduction of fire fuels, improvement of wildlife habitat. Should stimulate desirable forage species, and improve quantity and quality of big game range. Timing: April and September, 1980. Anticipated Completion Date: Completed.

Value to OIA Study: Geographic Area Covered: Montpelier Face, Worm Creek. Montpelier District, Caribou National Forest (Bear Lake County). Baseline Data: Not suitable. Further Study: Success of burn should be monitored. Burns on other areas should be considered. Potential for Use in Wildlife Management: Potential tool for big game winter range improvement.

Subjective Rating of Document: Valuable tool for improvement of big game winter range. Should be considered as off-site compensation for loss of habitat due to oil and gas exploration.

U.S. Forest Service. File 5150 - Fuel Management Prescribed burn: Red Mountain area. (RAW DATA).

Location: Montpelier District Office, Caribou National Forest, Montpelier, Idaho.

Contact Person: Ronald M. Walters (Wildlife Biologist).

Evaluation: Design: Proposed to burn and/or spray 2082 acres of sagebrush (2,4-D herbicide). Timing: Sept. - Oct. 1978. Anticipated Completion Date: Completed.

Value to OIA Study: Geographic Area Covered: Montpelier District, Caribou National Forest (Bear Lake County). Sandywash, Red Mountain, Preuss Creek, Whiskey Flat, Fox Flat, Twin Springs areas. Baseline Data: not suitable. Further Study: Success of treatment should be monitored. Negative effects on ground-nesting birds, such as sage grouse should be studied. Potential for Use in Wildlife Management: Valuable range management tool. Should be considered for increased use.

Subjective Rating of Document: Valuable tool for wildlife habitat improvement on OIA study area. Possible means of off-site compensation for habitat loss due to oil and gas impacts.

Comment: Herbicide is poisonous, may have some lingering effects on fishery, wildlife, watershed. Bare soil is exposed during burns, may cause erosion and impact fishery, watershed.

U.S. Forest Service. File 5150 - Fuels Management. Prescribed burn: Sage Valley Sagebrush. (ANALYZED DATA).

Location: Montpelier District Office, Caribou National Forest, Montpelier, Idaho.

Contact Person: Ronald M. Walters (Wildlife Biologist).

Evaluation: Design: Environmental assessment. Prescribed to reduce sagebrush densities in burned areas, to increase production of grasses. Spring burning was unsuccessful due to lack of understory to carry fire. Sagebrush is killed by fire. Dried grass is burned away. Soil moisture protects viable portions of grass root crowns, so grass will recover and vigorously resprout. Elimination of sagebrush will allow grasses to increase in production and vigor. Area was sprayed with 2,4-D to achieve same effect. Timing: May-June 1982.

Anticipated Completion Date: Completed.

Value to OIA Study: Geographic Area Covered: Sage Valley, Montpelier District, Caribou National Forest (Bear Lake County). Baseline Data: Not suitable. Further Study: Success of burn should be monitored. Possible negative effects on sage grouse should be studied. Potential for Use in Wildlife Management: Potential tool for range improvement. Designed to improve range for livestock, but would also benefit sharp-tailed grouse (possibly sage grouse).

Subjective Rating of Document: Valuable as potential range improvement tool. Should be considered as off-site compensation for habitat lost in oil and gas exploration.

U.S. Forest Service. 1978. Final Environmental Statement and Land Management Plan, Bear River Planning Unit, Caribou National Forest, Intermountain Region. 356 pp. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Assessment of phosphate mining oil and gas exploration, grazing and logging impacts. Impacts to wildlife and fisheries are addressed in detail. Area considered is mostly in Bear Lake County. Important populations of big game and game birds occur on the area, as well as important fish populations. Area is broken into 8 sub-units. Timing: 1976-1978. Analysis Methods: Cost-benefit analysis of various management alternatives. Tabulation of acreages, recreation visitor-days, etc. ✓

Value to OIA Study: Planning alternatives were chosen to impact wildlife resources as little as possible. Some long and short-term impacts are unavoidable. These included habitat loss for big game and game birds, stream sedimentation and channel changes, and increased vehicle traffic. Management will be oriented towards maintaining or enhancing wildlife and fish populations, maintaining critical or unique habitats, favoring big game in conflict areas, placing special emphasis on stream areas critical for fish survival (spawning and migration routes). Baseline Data: Wildlife summaries are too qualitative to serve as baseline data.

Subjective Rating of Document: Summary of wildlife and fishery resources on OIA study area. Provides valuable assessment of potential impacts to wildlife resource resulting from various land uses.

U.S. Forest Service. 1978. Final Environmental Statement and Land Management Plan, Bear River Planning Unit. Caribou National Forest, Intermountain Region, 356 pp. (MAPPING).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Type of Map: Habitat

Area Covered: U.S.F.S. Bear River Planning Unit, Caribou N.F. (includes Bear Lake County).

Scale: 1" = 2 miles.

Evaluation: Habitat Types Mapped: mule deer, elk, moose, winter range, elk calving areas, deer migration routes, blue & sage grouse habitat, sandhill crane, whooping crane and waterfowl habitat, trout streams.

5 vegetation cover types, 6 land type associations, oil and gas leases. Resolution: Blue grouse, 100 acres. Big game winter range 200 acres, etc. Ground Truthed? Unknown.

Subjective Evaluation of Mapping System: Useful baseline information for various wildlife species on OIA study area.

U.S. Forest Service. 1978. Final Environmental Statement and Land Management Plan, Diamond Creek Planning Unit. Caribou National Forest, Intermountain Region, 370 pp. (ANALYZED DATA).

Location: Soda Springs District Office, Caribou National Forest, Soda Springs, Idaho.

Evaluation: Design: Assessment of phosphate mining, oil and gas exploration, grazing, and logging impacts. Impacts to wildlife and fisheries were addressed in detail. Important populations of big game and game birds occur on the area, as do important fish populations.

Timing: 1976-1978. Analysis Methods: Cost-benefit analysis.

Tabulation of acreages, results of various management alternatives, recreation visitor-days, etc.

Value to OIA Study: Conclusions: The planning alternative chosen will impact wildlife and fisheries as little as possible. Some long- and short-term impacts are unavoidable, however. These include habitat loss for big game and game birds, stream sedimentation and channel changes, and increased vehicle traffic. Management will be oriented towards maintaining or enhancing wildlife and fish populations, maintaining critical or unique habitats, favoring big game in conflict areas, placing special emphasis on stream areas critical for fish survival, such as spawning or migration routes.

Subjective Rating of Document: Summary of wildlife and fishery values on area (including Georgetown Canyon area of Bear Lake County). Provides valuable assessment of potential impacts to wildlife and fisheries.

U.S. Forest Service. 1978. Final Environmental Statement and Land Management Plan. Diamond Creek Planning Unit. Caribou National Forest, Intermountain Region. 370 pp. (MAPPING).

Location: Soda Springs District Office, Caribou National forest, Soda Springs, Idaho.

Type of Map: Habitat.

Area Covered: U.S.F.S. Diamond Creek Planning Unit, Caribou National Forest (includes northern Bear Lake County - Georgetown Front, Georgetown Canyon).

Scale: 1" = 2 miles.

Evaluation: Habitat Types Mapped: mule deer, elk winter range, moose winter range, elk calving areas, blue grouse habitat, deer migration routes, sandhill crane, whooping crane and waterfowl habitat, trout populated streams. 5 vegetation cover types, 6 landtype associations, oil and gas leases. Resolution: Blue-grouse; 100 acres. Big game winter range; 200 acres, etc. Ground Truthed? Unknown.

Subjective Evaluation of Mapping System: Useful information for baseline in Bear Lake County.

U.S. Forest Service. 1982. (Draft) Forest Plan, Caribou National Forest, Fish and Wildlife resources on the Caribou National Forest. Caribou National Forest, Pocatello, Idaho. (ANALYZED DATA)

Location: Soda Springs District Office, Caribou National Forest, Soda Springs, Idaho.

Evaluation: Design: Provides a set of guidelines for managing wildlife on the Caribou National Forest. Fish and wildlife habitats are described. Twelve Management Indicator Species (MIS) were chosen. These are sensitive species (threatened or endangered, game species, of special interest, or serving as an indication of well-being of a habitat), which are managed as typical of a certain habitat. Their requirements are usually such that a variety of other species are adequately managed for, if the MIS are. Estimates were made of minimum viable population size, and estimates given for each major watershed. Other sensitive species were listed. Timing: 1982. Analysis Methods: Population estimates are extrapolated from a variety of sources. Big game estimates follow Kuck et al. 1982. Based on habitat use and numbers of Cooperative-Wildlife Phosphate area, Fish estimates are from stream surveys, electro-shocking.

Value to OIA Study: Conclusions: MIS were chosen: bald eagle (snags, riparian), mule deer and elk (early forest succession), Goshawk (Old growth conifer), hairy woodpecker (snags), yellow-bellied sapsucker (aspen, riparian), 4 trout species (aquatic). Other sensitive species on Montpelier District include bobcat, lynx (?), river otter - ferruginous hawk, prairie falcon. Whooping cranes (endangered) are also a possibility if re-introduction at Grays Lake succeeds. Providing for habitat requirements of these species should also provide for other species, whose specific habitat requirements are not well known. 350 vertebrate species on the forest are listed, with rough habitat designations. Bloomington Lake, Montpelier Reservoir, and Elk Valley Marsh are cited as important aquatic habitats on the Montpelier District. Management of wildlife will be according to previous wildlife management plans and Idaho Department of Fish and Game goals. Specific strategies for minimizing effects of mineral exploration, road construction, stream erosion, logging, and grazing are given. Management alternatives were chosen giving consideration to wildlife needs. Baseline Data: Population estimates for MIS given for Montpelier District (Bear Lake County). Further Study: Specific habitat requirements of sensitive species, and others, should be studied. MIS will be monitored.

Subjective Rating of Document: Valuable summary of current status of sensitive species and habitats. Useful listings of strategies for minimizing mineral exploration impacts on wildlife.

U.S. Forest Service. 1981. Key wildlife area maps. Unpublished maps, USFS, Caribou NF. (MAPPING)

Location: Soda Springs District Office, Caribou National Forest, Soda Springs, Idaho.

Contact Person: Marilyn Hemker (Wildlife Biologist)

Type of Map: Habitat.

Area Covered: Caribou National Forest, includes Bear Lake County area (Montpelier District).

Scale: 1:24000.

Evaluation: Habitat Types Mapped: Elk, mule deer, moose winter areas, elk calving areas, deer migration routes. Areas mapped onto U.S.G.S. Orthophoto quads.

Resolution: 1/4 mile diameter.

Ground Truthed? No. (Some areas ground truthed on Montpelier).

Evaluation: Year of Original Mapping: 1980.

Subjective Evaluation of Mapping System: Valuable information on big game, blue grouse in Bear Lake County.

Comment: Source--Idaho Department of Fish and Game.

U.S. Forest Service. Fisheries Data on Forest Streams. (RAW DATA).

Location: Soda Springs District office, Caribou National Forest, Soda Springs, Idaho.

Contact Person: Dean Grover (Fisheries Biologist).

Evaluation: Design: Evaluation of streams on Caribou National Forest, by watershed. For each stream, gives km. on forest, stream order, qualitative rating of fishery, and estimate of angler-days fished. Each fishery is rated as to quality of fishery and quality of information about fishery. Timing: compiled in 1978 from data 1973-1978.

Value to OIA Study: Geographic Area Covered: Includes northern Bear Lake County -- Geneva, Montpelier, Georgetown watershed. Baseline Data: Baseline data-additional information will be collected as time permits. Potential for Use in Wildlife Management: Indication of quality of fishery resource, and angler interest in each stream in area.

Subjective Rating of Document: Useful documentation of fishery resource in OIA area. Could be valuable for identifying sensitive areas.

U.S. Forest Service. Map: Predation problems. (MAPPING).

Location: Montpelier District Office, Caribou National Forest, Montpelier, Idaho.

Contact Person: Ronald M. Walters (Wildlife Biologist).

Type of Map: Habitat.

Area Covered: Caribou National Forest (includes Bear Lake County).

Scale: 1" = 5 miles.

Evaluation: Habitat Types Mapped: Maps areas where livestock losses to predators (coyotes) occur (less than, greater than 1% of sheep herds).

Resolution: Diameter-2 miles. Ground Truthed? Unknown.

Subjective Evaluation of Mapping System: Useful information on predation problems on OIA study area. Could be used to qualitatively describe coyote populations.

Comment: Important problem, especially in Georgetown Canyon area.

U.S. Forest Service. 1981. Map: Wildlife orthophoto quads. Unpublished maps, USFS, Caribou NF. (MAPPING).

Location: Montpelier District Office, Caribou National Forest, Montpelier, Idaho.

Contact Person: Ronald M. Walters (Wildlife Biologist).

Type of Map: Habitat.

Area Covered: Montpelier District, Caribou National Forest (Bear Lake County).

Scale: 1:24,000

Evaluation: Habitat Types Mapped: Various wildlife habitats (Forest Service lands) mapped onto U.S.G.S. 7-1/2' orthophoto quad maps. Elk, mule deer, moose - summer and winter, elk calving areas. Blue and sage grouse - breeding, summer, winter. Bald eagle hunting and feeding areas. All qualified as either high or very high value. Detailed mapping of habitats. Resolution: Diameter - 1/4 mile. Ground Truthed? Unknown.

Subjective Evaluation of Mapping System: Valuable indication of important wildlife habitats in Bear Lake County. Should be considered in assessing impacts of oil and gas exploration on Forest Service lands.

U.S. Forest Service. Map: Wildlife overlay. (MAPPING).

Location: Montpelier District Office, Caribou National Forest, Montpelier, Idaho.

Contact Person: Ronald M. Walters (Wildlife Biologist).

Type of Map: Habitat.

Area Covered: Montpelier District, east. (Bear Lake County).

Scale: 1" = 0.5 miles.

Evaluation: Habitat Types Mapped: Overlay to District multiple-use planning map. (Forest Service lands). Elk, mule deer - winter range, key area winter range. Sage grouse vegetation study enclosures, browse transects study areas, Parker "3-step" study area. Stream fishery habitat, beaver colony. Resolution: Diameter 1/4 mile. Ground Truthed? Unknown.

Subjective Evaluation of Mapping System: Valuable information on wildlife values on Forest Service lands. Should be considered in assessing oil and gas impacts on OIA area.

Comment: Less detailed than U.S.F.S. Map: Wildlife-orthophotoquads.

U.S. Forest Service. Map: Wildlife/Vegetation types. (MAPPING).

Location: Montpelier District Office, Caribou National Forest, Montpelier, Idaho. (MAPPING).

Contact Person: Ronald M. Walters (Wildlife Biologist).

Type of Map: Habitat.

Area Covered: Montpelier District, Caribou National Forest (Bear Lake County).

Scale: 1:24,000.

Evaluation: Habitat Types Mapped: Various wildlife habitat areas mapped onto detailed vegetation maps: elk, mule deer, moose-summer and winter range, elk calving areas. Blue and sage grouse areas, summer and winter. Sage grouse current and historical distribution. All qualified as either high or very high value. Resolution: Diameter - wildlife 1/4 mile, vegetation, 0.1 mile. Ground Truthed? Unknown.

Subjective Evaluation of Mapping System: Valuable information on habitat use by important species. Should be considered in assessing impacts of oil and gas exploration on OIA study area.

Comment: Same base data as U.S.F.S. Map: wildlife orthophotoquads.

U.S. Forest Service. 1978. A program for fish and wildlife habitat on the National Forests and Grassland in Idaho. Northern and Intermountain Regions, U.S.D.A. Forest Service. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello.

Evaluation: Overview of proposed programs, priority for wildlife and fisheries resources on National Forests. Timing: 1978. Analysis

Methods: Data tabulated by forest. Estimates of populations, harvests taken from many sources, including Idaho Department of Fish and Game.

Value to OIA Study: Idaho has a great diversity of wildlife, over 500 species. Specific goals and objectives are 1) produce more fish and wildlife on National Forests, 2) recognize and enhance wildlife-based recreation potentials, 3) Intensify management to protect and enhance existing populations, and 4) sustain and improve diversity of present habitats. Statewide populations and harvest intensities, 5-year summary of habitat improvements are given. Proposed cost of programs for next 5 years on Caribou Forest given. Baseline Data: not suitable.

Subjective Rating of Document: General overview of Forest Service priorities. Regional nature does not lend itself to direct use as baseline information.

U.S. Forest Service. 1979. A program for threatened, endangered, and sensitive species on the Caribou National Forest and Curlew National Grasslands. 36 pp. File: Endangered Species (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Outline of management direction for Caribou Forest during next 5 years. Status of species will be monitored, and habitats protected. Review of status, location, distribution given.

Timing: 1979.

Analysis Methods: None.

Value to OIA Study: Conclusions: Details of 3 T&E plants, 4 endangered animals on Montpelier District given, also information on "sensitive" species. Threatened plant - Starveling mile vetch - Whiskey flat, Snowslide Canyon, Montpelier Creek. Davis thistle - Georgetown Canyon, Montpelier Canyon. Endangered Plant - Cryptantha breviflora - Crow Creek Road, Montpelier Reservoir. Endangered Animals - Bald Eagle - various wintering areas. Peregrine falcon - few sightings, historic nesting areas. Wolf - could be expanding range to Bear Lake County. Whooping Crane - could be expanding range to Bear Lake County. Baseline Data: Some value as baseline information. Further Study: Status should be monitored for each species.

Subjective Rating of Document: Valuable information on T&E plants and animals. Should be considered in assessing oil and gas impacts on OIA study area.

Utah Division of Wildlife Resources, 1980. Summary of 1980 Cisco season activities. Unpublished report. 9 pp. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Pocatello, Idaho.

Evaluation: Design: Fisherman use and cisco harvest estimates were made at Bear Lake, Utah-Idaho during the cisco spawning periods Jan. 20-29, 1980. Car-counters were used, with interviews, to estimate number of cars, number of netters/car. Fish were collected and measured during run, as well as from gill nets (October 1979). Similar data collected each year. Timing: 1980. Analysis Methods: Data tabulated (totals, means, percents). Length frequencies (%).

Value to OIA Study: Conclusions: 151,133 cisco were harvested by 4207 fisherman in 1981. Harvest data presented since 1962. Length frequencies, sex distribution indicate fishery is not over-harvested. Similar data available since 1962. Baseline Data: Valuable baseline data for Bear Lake Cisco fishery. Further Study: Continue collecting similar data.

Subjective Rating of Document: Valuable data on Bear Lake cisco fishery. Should be considered in impacts of oil and gas exploration on OIA study area.

Vilkitis, J.R. 1968. Characteristics of big game violators and extent of their activity in Idaho. Thesis. University of Idaho, Moscow, Idaho. 202 pp. (ANALYZED DATA).

Location: Idaho Department of Fish and Game, Soda Springs, Idaho.

Evaluation: Design: Objectives: Determine distinguishing characteristics of big game violators. Determine distribution, magnitude and composition of violations in Idaho. Similar questionnaires were sent to hunter and convicted violators (875 of each). Personal interviews were conducted with 29 sportsmen and 32 hunters, with questions on personal data, game laws, game violations, and enforcement personnel. Arrest records were analyzed for a 16-year period, for information on number of violations, season and area of violation, fines, and personal data. Violations were simulated, to determine index of detection rate. 31 big game animals were "illegally" taken. Timing: 1967. Arrest records were examined 1950-1965. Analysis Methods: Data tabulated (total, %, mean, variance). χ^2 , F-tests of significance.

Value to OIA Study: Conclusions: 2% of arrests occurred in Bear Lake County. 38% of questionnaires were returned. Descriptions of violators and hunters are given, and their responses to observed violations. Simulated violations were seldom reported. An estimated 3700-8000 big game animals were killed out-of-season (throughout the state) from January-June 1967. Baseline Data: Not suitable. Further Study: Numerous recommendations for further work given, including an index to "undetected" violations and techniques for preventing violations.

Subjective Rating of Document: Valuable indication of extent, nature of serious wildlife management problem. Should be considered in assessing impacts of industrial development.

Waldrip, G. 1981. Environmental Assessment. Snowdrift Mountain - Diamond Peak Aspen Management Unit. Soda Springs and Montpelier Ranger Districts, Caribou County Idaho. Caribou National Forest. 31 pp. (ANALYZED DATA).

Location: USFS, Soda Springs Ranger Station, Soda Springs, Idaho.

Western Caribou County (borders northern Bear Lake County). Soda Springs and Montpelier Ranger Stations.

Evaluation: Design: Assess need and methods for rejuvenating Aspen stands. Criteria considered included: air and water quality, impacts on big game species, other wildlife, threatened and endangered species, fish, visual resource, and fuelwood resource. Nine indicator species were chosen: mule deer, elk, moose, beaver, ruffed grouse, yellow-bellied sapsucker, downy woodpecker, mountain bluebird, rufous-sided towhee. Prescribed burning and herbicide spraying were considered as methods to replace natural historic burning as agent for successional retrogression. Timing: 1981. Analysis Methods: literature review, qualitative description.

Value to OIA Study: Conclusions: Aspen was shown to be an important resource for 3 big game species, many other wildlife species. 63% of Aspen in the area is over 60 years old, approaching senility. It was concluded to rejuvenate 500 acres/year for the next 30 years, by a combination of prescribed burning, cutting and spraying with herbicide. This would create a mosaic of vegetational types, improving area for wildlife (helping to meet Idaho Department of Fish and Game goals), and for grazing. Baseline Data: indicates range of problems associated with aspen management, value of aspen stands to wildlife. Further Study: Mitigation of impacts of oil and gas exploration through aspen rejuvenation may be economically feasible. Subjective Rating of Document: Because of nearness of area to Bear Lake County, serves as a valuable description of wildlife problems on OIA study area.

Wallace, R.L. 1978. The Bonneville cutthroat trout, Salmo clarki utah, in Idaho waters. Unpublished report, University of Idaho, Moscow. 3 pp. (ANALYZED DATA).

Location: Soda Springs District Office, U.S. Forest Service, Soda Springs, Idaho.

Evaluation: Design: Summary of information on Bonneville cutthroat (see Wallace 1978). Timing: 1978. Analysis Methods: None.

Value to OIA Study: Conclusions: Recently rediscovered Bonneville cutthroat is essentially pure sub-species, should be recognized and protected as valuable native fishery resource in Idaho (catch and release fishing, and possible stocking elsewhere). Current management practices must be modified to enhance population: all stocking of non-native salmonids in Giraffe Creek should be stopped, aquatic habitat must be protected, grazing reduced or eliminated, other efforts made to protect drainage. Baseline Data: Important baseline data for Bear Lake County. Bonneville cutthroat found in Giraffe Creek and Raymond Creek, WY. (Northern Bear Lake County and Western Lincoln County, WY). Further Study: Plans should be made for protecting these drainages.

Subjective Rating of Document: Valuable data for OIA study area. Speices is potentially threatened.

Comments: Bonneville cutthroat originally occurred throughout Bonneville Basin - Utah, eastern Nevada, southwestern Wyoming, southeastern Idaho. Overfishing and introduction of rainbow, brook, brown, and non-native cutthroat trouts led to accelerated loss of this sub-species. Believed by some to be extinct by 1950's it has been rediscovered in the Bear River drainage. It is considered "endangered" by Bonneville Chapter, American Fisheries Society "status undetermined" in 1973 U.S.D.I. "Red Book" of endangered species, "Sensitive" by Wyoming Game and Fish Department (1977).

Wallace, R.L. 1978. Report on purity of Bonneville Cutthroat Trout, Salmo clarki utah, from upper Giraffe Creek, Bear River Drainage, Idaho.

Unpublished report, University of Idaho, Moscow. 5pp. (ANALYZED DATA)

Location: Soda Springs District Office, U.S.F.S., Soda Springs, Idaho.

Evaluation: Design: Population sampled (N=30) to determine degree of purity. Meristic characters counted, vertebrae x-rayed, scales counted, spotting pattern noted. Results compared to typical Bear River drainage specimens; Giraffe Creek, WY specimens from 1973, and Raymond Creek, WY specimens from 1976 (latter two groups also from Thomas Fork drainage). Timing: July 1978. Analysis Methods: Data tabulated, with means.

Value to OIA Study: Conclusions: Populations concluded to be nearly pure. This is the first evidence of Bonneville cutthroat in Idaho. Sub-species considered valuable fishery resource in Idaho. Baseline Data: Important baseline information for Bear Lake County.

Subjective Rating of Document: Valuable information for Bear Lake County. Streams mentioned are tributaries of Bear River, in northern Bear Lake County and western Lincoln County, WY.

Comments: Most populations of cutthroat trout have been reduced or exterminated through overfishing and introduction of non-native trout, especially rainbow trout. Bonneville cutthroat trout was considered extinct by some authors, but a few populations have been discovered.

White, R.G. 1974. Endemic Whitefishes of Bear Lake, Utah-Idaho: A Problem in Systematics, Dissertation. Utah State University, Logan, Utah. (ANALYZED DATA)

Location: Utah State University Library, Logan, Utah.

Evaluation: Design: Collections of whitefish were made in Bear Lake using an 8.2 m. semi-balloon otter trawl or horizontal sinking multi- and monofilament nylon gillnets for study of systematics.

Timing: June 1969-December 1972. Analysis Methods: Sex, state of maturation, length, weight, data, time, location, depth, and method of capture. Data recorded. Morphological and electrophoretic analyses. Hybridization studies. Multiple discriminant function analysis for comparisons with Morphological differentiations.

Value to OIA Study: Conclusions: Morphological, ecological, and hybridization analyses provided evidence for separate recognition of 2 forms of Bonneville whitefish. Baseline Data: Baseline data on distribution of whitefish in Bear Lake. Further Study: None recommended.

Subjective Rating of Document: Has little value for OIA study. A systematics study only.

Winn, D.S. 1976/ A description of aspen communities and related wildlife populations in the phosphate strip mining area of southeastern Idaho. Caribou National Forest, U.S.F.S. 60pp. (ANALYZED DATA)

Location: Soda Springs District Office, Caribou National Forest, U.S.F.S. Soda Springs, Idaho.

Evaluation: Design: Inventory major terrestrial vertebrate populations in aspen communities. Describe vegetation major aspen communities. Relate indices of vertebrate populations to aspen community types. Vegetation was analyzed using standard plot techniques. Birds were censused using 3, 1.5 hour counts over adjacent 5 acres per stand. Small mammals were inventoried using large snap traps, 300 trap-nights over 1.2 acres. Sign of larger mammals (pellets, squirrel middens, gopher mounds, etc.) was also recorded. Timing: Summer 1976. Analysis Methods: Data was extensively analyzed. Plant communities: coefficient of similarity, cluster analysis, mean, standard errors, percent. Animals: mean, standard error, #/plot, #/trap-night, Birds: #/hr. #/plot. Comparative ratios.

Value to OIA Study: Conclusions: Detailed vegetation descriptions of 6 aspen community types was provided (based on 2900 plots), 29 stands), on Soda Springs Ranger District. Numbers of large and small mammals, birds were related to community types. 13 species of small mammals were trapped. The most common species were yellowpine chipmunk, red squirrel, northern pocket gopher, deer mouse, and boreal redback vole. 7 larger mammals were sighted or sign observed. 40 bird species were observed. Most common species were yellow-bellied sapsucker, tree swallow, black-capped chickadee, robin, warbling vireo. Bird species appear more reliant on community structures, mammals on patterns of vegetation. Baseline Data: Valuable data on abundance of birds and small mammals in aspen communities. Further Study: Recommends establishment of permanent sampling plots in manipulated and undisturbed stands. Community types as well as structure (such as accumulated down wood, understory biomass, canopy coverage) should be further studied. Management of aspen types should be directed at structural diversity.

Subjective Rating of Document: Valuable data on abundance of birds, small non-game mammals, larger mammals in Aspen types. Information on assessing results of conversion of one aspen type to another. Results should be similar to OIA study area, because of similar habitats.

Wilson, L.O. 1975. Distribution, season of use, and habitat of the mammals, birds, reptiles, amphibians, and fishes of Idaho. Bureau of Land Management, Boise, ID. 110pp. (ANALYZED DATA)

Location: Soda Springs Resource Area Headquarters, Bureau of Land Management, Soda Springs, Idaho.

Evaluation: Design: Distribution of all vertebrate species in Idaho, based on any available data. Mapped on very large-scale map. Brief description of season of use, habitat, food habits. Timing: 1975, updated, 1977, 1979. Analysis Methods: None.

Value to OIA Study: Conclusions: Listing of species in state. Baseline Data: Limited value as baseline data.

Subjective Rating of Document: Some value as indication of presence of species in Idaho. Useful information for any study of non-game animals.

Comments: The following species classified "sensitive" by BLM may occur in Bear Lake County area: Bobcat, Canada lynx, white-faced ibis, ferruginous hawk, bald eagle (endangered), osprey, peregrine falcon (endangered), merlin, gyrfalcon, sharp-tailed grouse, whooping crane (endangered, Grays Lake area), long-billed curlew.

Wood, B.A. and E.H. Merrill. 1979. Federal aid to wildlife restoration. Southeast Idaho Wildlife Studies. Literature review. Job Progress report. Project W-160-R-6. Idaho Department of Fish and Game. Soda Springs, ID. 88pp. (ANALYZED DATA)

Location: Prepared in conjunction with big game studies in Caribou, Bear Lake counties. IDFG, Soda Springs.

Evaluation: Design: Literature review of impacts of surface mining on big game in the western United States. Impacts include changes in quantity or quality of habitat, and harassment from increased activity, road access.

Value to OIA Study: Conclusions: Insufficient research has been done on impacts to big game. This literature review can serve as planning tool for government agencies or private industry, interested in minimizing adverse effects and increasing benefits from rehabilitation. Recommendations were made regarding big game habitat, revegetation (plant types, planting techniques), harassment, and road construction and access. Further Study: Effects of harassment, and increasing human activities resulting from increased access (especially illegal harvest) should be investigated.

Subjective Rating of Document: Extensive literature review. Valuable recommendations made for reclamation/revegetation, avoidance of harassment and reducing impacts of access roads.

Appel, R.R. 1971. The effects of artificial nesting structures on Canada goose activities in the upper Bear River valley. Unpubl. M.S. Thesis, University of Wyoming, Laramie, WY. (ANALYZED DATA)

Location: University of Wyoming, Laramie, Science Library

Evaluation: Design: 3 nesting areas along Bear River, one is seven miles south of Cokeville, two is 12 miles south of Cokeville, three is three miles northeast of Randolph, UT. Nesting structures on number one only, other two sites are controls. For each of the three nesting areas habitat maps were prepared, nesting surveys conducted, aerial and ground census and brood counts made. Comparisons of nesting structure use with counts made since 1953.

Timing: 1 field season. Analysis Methods: Qualitative comparisons of nesting success in different nesting areas.

Value to OIA Study: Confirms: Where nesting habitat is limited or inundated by irrigation, nesting structures increase goose productivity. Baseline Data: Nesting areas near or peripheral to study area, are of limited size.

Use in Wildlife Management: Useful demonstration of importance of nesting structures as enhancement project.

Subjective Rating of Document: Old data (1968), limited geographically though within study area. Confirms importance of study area to nesting Canada geese.

WYOMING

Base, D., E. Raper, and G. Pivonka. 1983. Distribution and relative abundance of selected wildlife species within the Bear River Divide area of southwestern Wyoming, December 1981 through May 1983. Unpublished Final report to the Overthrust Industrial Association, Wyoming Game and Fish Department, Green River. (ANALYZED DATA)

Location: WGF, Green River, Wyoming.

Contact: Elaine Raper.

Evaluation: Design: Varied by species examined. Aerial and ground surveys of big game each month. Surveys of wintering bald eagles at Woodruff Narrows roost. Ground surveys for black-footed ferrets on Cumberland Flats. Sage grouse lek surveys on active lek sites from April to May. Raptor nest site surveys from March to June. Results: Mapped distributions of wintering mule deer, pronghorn, and moose on Bear River Divide. Mapped transitional distributions (from winter to summer range) for mule deer, pronghorn, and moose. Percentages of observations of big game (mule deer, pronghorn, and moose) occurring in various habitat types (sagebrush-grassland, juniper-sagebrush, serviceberry-sage, willow riparian shrub, greasewood-saltbush, mixed shrub, grassland/meadow, aspen, aspen-serviceberry, aspen-sagebrush, serviceberry, disturbed bare, and oil & gas sites); numbers and percentages observed on different slopes and slope aspects; and distances (class categories) of big game observed to nearest human activity (drill sites, pipelines, roads, and miscellaneous work). Sage grouse occurrence by habitat type, elevation, snow depth, slope and aspect. Examination of 51 sagegrouse lek sites within the Bear River Divide, 36 of which were active in 1983. Habitat characteristics of lek

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Value to OIA Study: Conclusions: Where nesting habitat is limited or inundated by irrigation, nesting structures increase goose productivity. Baseline Data: Nesting areas near or peripheral to study area, are of limited size.

Use in Wildlife Management: Useful demonstration of importance of nesting structures as enhancement project.

Subjective Rating of Document: Old data (1968), limited geographically though within study area. Confirms importance of study area to nesting Canada geese.

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Location: WGFD, Green River, Wyoming.

Contact: Elaine Raper.

Evaluation: Design: Varied by species examined. Aerial and ground surveys of big game each month. Surveys of wintering bald eagles at Woodruff Narrows roost. Ground surveys for black-footed ferrets on Cumberland Flats. Sage grouse lek surveys on active lek sites from April to May. Raptor nest site surveys from March to June. Results: Mapped distributions of wintering mule deer, pronghorn, and moose on Bear River Divide. Mapped transitional distributions (from winter to summer range) for mule deer, pronghorn, and moose. Percentages of observations of big game (mule deer, pronghorn, and moose) occurring in various habitat types (sagebrush-grassland, juniper-sagebrush, serviceberry-sage, willow riparian shrub, greasewood-saltbush, mixed shrub, grassland/meadow, aspen, aspen-serviceberry, aspen-sagebrush, serviceberry, disturbed-bare, and oil & gas sites); numbers and percentages observed on different slopes and slope aspects; and distances (class categories) of big game observed to nearest human activity (drill sites, pipelines, roads, and miscellaneous work). Sage grouse occurrence by habitat type, elevation, snow depth, slope and aspect. Examination of 51 sagegrouse lek sites within the Bear River Divide, 36 of which were active in 1983. Habitat characteristics of lek

sites are provided. Distribution maps of bald eagle and rough-legged hawk wintering areas and habitat characteristics of observations related to feeding, resting and flying behaviors for these 2 species and for golden eagles. Numbers of active nests and general habitats for 5 raptor species. Relative abundance and species diversity (in terms of number of species observed) for birds and mammals seen in various habitat types within the Bear River Divide. Appendix A provides a checklist of birds observed during the project period. Appendix B provides similar information for mammals. Analysis methods: Quantitative evaluations of frequency of occurrence by habitat type for big game, sage grouse, and raptors (including bald eagles) but no hypothesis testing with the results. Qualitative distributions and occurrence of other wildlife species.

Value to OIA Study: Study area includes the entire Bear River Divide but does not extend south of I-80 nor north of US 30. These baseline data greatly improve local knowledge on distributions, habitat associations, and species occurrence within the Bear River Divide. Further Study: While this particular project is terminated, the results will serve as baseline information upon which additional surveys on the extended study area will build. Distribution of select species from human activities and within habitat types can be used for future site-specific studies if stratification of sampling effort is necessary.

Subjective Rating of Document: The report, itself, is a summary but actual data obtained during the study could provide more site-specific information, possibly useful for development and post-development comparisons.

Baxter, G.E. 1968. Mountain mahogany regeneration demonstration.

Unpubl. report, USFS, Cokeville Ranger District, Bridger-Teton National Forest, Cokeville, WY. (ANALYZED DATA)

Location: Kemmerer Ranger District Office, Kemmerer, WY.

Evaluation: Design: eight individual trees cut, photos taken before and after cutting. Cuttings in spring and autumn. Location: Near Grade Creek and Hawkins Creek in Tunp Range. Timing: Date of treatment unknown. Analysis Methods: Subjective rating of re-growth.

Value to OIA Study: Conclusions: 75 % of treated trees had some form of new growth, better response from spring cutting than fall cutting. Baseline Data: no data, descriptive study. Use in Wildlife Management: Potential treatment for degenerate stands of mountain mahogany, as mitigative procedure.

Subjective Rating of Document: Usefulness of treatment would have to be tested on study area under controlled conditions. Otherwise the study is a one time event, no known follow-up study. Study was conducted north of BRD study area.

Baxter, G.T., and J.R. Simon. 1970. Wyoming fishes. Wyoming Game and Fish Department, Bulletin No. 4, Cheyenne, WY. 168pp. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: Design: Historical and recent (pre-1970) accounts of game and non-game fish species in Bear & Green River drainages. Taxonomic keys to species. General habitat requirements and

Baxter and Simon 1970, cont.

life history phenomena. Analysis Methods: Qualitative descriptions of species occurrence, habitats, etc. based on published literature and state-wide surveys (pre 1970).
 Value to OIA Study: Background information on which species are likely to occur in local drainages on study area.
 Subjective Rating of Document: Useful as field guide, nothing of quantitative data. Cannot serve as baseline information except to point out species occurrence.

Baxter, G.T., and M.D. Stone. 1980. Amphibians and reptiles of Wyoming. Wyoming Game and Fish Department, Bulletin No. 16, Cheyenne, WY. 137pp. (ANALYZED DATA).
 Location: WGFD, Cheyenne, WY.
 Evaluation: Design: Herpetofauna occurrence in Wyoming from museum collections and published records. Species' descriptions, ranges, and natural history. Species' distribution maps and sites of collection. Analysis Methods: Qualitative descriptions of species occurrence, habitats, etc.
 Value to OIA Study: General background information on which species are likely to occur in study area.
 Subjective Rating of Document: Useful as field guide.

Beetle, A.A., and C.B. Marlow. 1974. A vegetative survey of Fossil Butte National Monument, Kemmerer, Wyoming. University of Wyoming Cooperative Research Report to Yellowstone Environmental Studies Center, Part II. (ANALYZED DATA)
 Location: University of Wyoming, Dept. Range Science, Laramie, WY.
 Contact: Alan Beetle.
 Evaluation: Design: No survey methods are presented although locations of sampling sites and collection sites for herbarium collections are provided on maps (scale unknown). Analysis methods: Plant species lists (trees, shrubs, grasses, and forbs) are given for each of the following plant communities: mixed timber and shrub, aspen, alkalie sagebrush and grass, mountain big sagebrush and shrub, mountain big sagebrush and grass, basin big sagebrush, shadscale saltbush and shrub, shadscale saltbush and alkali sagebrush, serviceberry, mountain mahogany and service berry, mountain mahogany, mixed shrub, chokecherry and antelope bitterbrush.
 Value to OIA Study: Location: Just north of the BRD study area. Conclusions: Plant communities and soils associations are briefly discussed. Most of the discussion centers on the influences of livestock, feral horses and big game on the available forage, especially near water. The effects of saltblock placement near water compounds the grazing pressures on these areas. These conclusions appear to be based on subjective evaluations of vegetation in the survey area.
 Subjective Evaluation of Document: No quantitative data are presented for use in future comparisons. The plant community species lists are valuable for use in future inventories. Overall, the report is a subjective description of vegetation and interactions with ungulate species and of little value except to point out that over utilization may be occurring.

Behnke, R.J. 1975. The native cutthroat trouts of Wyoming. Part I: The Green River and Bear River Drainages. Unpublished report, Colorado State University, Fort Collins, CO. (ANALYZED DATA)
 Location: Dept. Fishery and Wildlife Biology, CSU, Ft. Collins, CO
 Contact: Robert Behnke.

Evaluation: Design: Green River (Colorado River) cutthroat trout collected during 1972 were evaluated for strain purity. Geographic location: Blacks Fork drainage tributaries include West Fork Muddy Ck, Van Tassel Ck., Beaver Dam Hollow, Muddy Ck., Gilbert Ck., and Archie Ck. Analysis: Quantitative evaluation of characters from cutthroat samples. Conclusion: Green River native cutthroat trouts generally appeared to resist extensive hybridization and may be superior genotypes to introduced species in these environments.

Value to OIA Study: Documentation of levels of genetic purity of Salmo clarki pleuriticus populations studied. Further Study: Information from populations studied needs to be combined with other, similar studies to assess how many S. C. pleuriticus populations have in fact been inventoried. Plans for future assessments of genetic purity and population levels can then be made.

Subjective Rating of Document: Useful for streams surveyed and when compiled with other studies can suggest other inventories to be done on specific streams and trout populations.

Behnke, F.J. 1976. An analysis and determination of Salmo clarki utah purity and significance in national resource land streams of the Thomas Fork drainage: with observations of aquatic habitat problems. Unpubl. report prepared for BLM, Rock Springs District, Kemmerer Resource Area, Kemmerer, WY. (ANALYZED DATA)
 Location: BLM, Rock Springs District Office, Rock Springs, WY.
 Contact: Bruce Smith.

Evaluation: Design: Collections of Bonneville cutthroat trout from different tributaries to the Bear River and identification of relative strain purity by tributary. Provides a description of environmental problems associated with Thomas Fork drainage streams and riparian areas related to unmanaged livestock grazing although no data are provided. Also, a list and discussion of management alternatives is included: elimination of grazing, fencing, livestock distribution, and mitigation possibilities. Analysis Methods: Quantitative evaluation of Bonneville cutthroat trout taxonomic status and purity in drainages examined. Qualitative discussion of trout environmental problems.

Value to OIA Study: Location is north of study area (T.26N to T28N, R118W to R119W). Management suggestions could be useful for riparian improvements implemented on the study area as mitigative efforts. Value of Bonneville cutthroat trout character analysis for use in BRD study area trout comparisons.

Subjective Rating of Document: With exception of management and mitigation recommendations, has little applicability to BRD study area.

Belitsky, D.W. 1981. Small mammals of the Salt Wells - Pilot Butte Planning Unit. Bureau of Land Management, Rock Springs District Office, Rock Springs, WY. 104 pp. (ANALYZED DATA)
 Location: BLM, Rock Springs District Office, Rock Springs, WY.
 Contact: Bruce Baker.

Evaluation: Design: Small mammal snap trapping, live trapping, pitfall traps, in different habitat types. Sixteen habitat types sampled and relative abundance of small mammals per type was calculated. Bats were sampled with mist nets. Species by habitat matrix developed. Comparisons of species-habitat occurrence with other published literature. Gives legal description of trapping transects and trapping dates. Timing: Study completed in 1979. Similar study to occur in Pioneer Trails Planning Unit.

Value to OIA Study: Location: Salt Wells - Pilot Butte Planning Unit is outside (east) of BRD study area, little direct value as baseline data. Further Study: When comparable data is available from Pioneer Trails Planning Unit this study may serve as comparisons of species abundance per habitat type, and for examining variations and consistencies within similar habitats.

Subjective Rating of Document: Repeatable methods and analysis for potential comparisons if similar data is collected on BRD study area.

Berry, J.D. 1982. Draft copy, Appendix D9 - wildlife surveys, Cumberland Coal Company South Haystack Mine. Unpublished report, Kiewit Mining and Engineering Company, Sheridan, WY. (ANALYZED DATA)
 Location: Kiewit Mining and Engineering Co., Sheridan, WY.
 Contact: Tom Dahmer.

Evaluation: Design: Varied by species group examined. Aerial surveys to determine mule deer and antelope occurrence in vicinity of mine permit area for numbers and habitat affiliations for both species. General observations of elk and moose are noted. Mustelids, canids, and felids observed opportunistically. Rodents sampled on eight live trap grids in representative habitat types on mine permit area. Population estimates (Jolly-Seber and Bailey estimators) for Peromyscus maniculatus in six habitat types. Lagomorphs surveyed by night spotlighting and by roadside transects in different habitat types. Prairie dog colonies surveyed during search for black-footed ferrets (see Martin and Schroeder 1979 and 1980, below). All burrows within each colony were counted and acreages computed. Sage grouse lek attendance and observations along a drive route for habitat use, brood size and broods per mile are documented. Sage grouse were telemetered and seasonal movements are summarized. Raptor nesting data for 10 species nesting within the study area was obtained 1977 to 1981. Passerine species diversity, density and seasonal habitat affinities were determined by flush transects and belt transects, Shannon-Weaver diversity indices were computed for each habitat type sampled as well as density estimates by species. Herpetofauna were observed opportunistically.

Berry 1982, cont.

Summary of USFWS black-footed ferret searches in 1978 and 1979 are presented. Timing: Planned to continue.

Value to OIA Study: Location: Study area is within BRD study area (T16N to T17N and R 117W to R118W). Methods and analyses are standard and replicable. Species occurrence and habitat affinities might serve as comparisons for studies conducted elsewhere in BRD study area.

Subjective Rating of Document: Some of the best information available for game and non-game vertebrates on BRD study area.

MAPPING: Type of map: Habitat. Area covered: approximately 21 sq.mi. area within T16N to T17N and R117W to R118W.

Scale: 1:12000 (1" = 1000').

Evaluation: Habitat types mapped: Bottomland big sagebrush, upland big sagebrush, upland grass, impoundment(disturbed area), saltbush/greasewood, low sage, deciduous mountain brush, juniper, barren rock or soil, aspen. Also mapped are locations of small mammal transects and passerine transects. Resolution: Less than 2 acres. Ground Truthed: Yes.

Subjective Evaluation of Map: While the area covered is limited many of the habitat types likely to occur in the BRD study area are examined and might serve for future comparisons.

MAPPING: Type of map: Wildlife use areas. Area covered: Same as above. Scale: 1:24,000.

Evaluation: Information mapped: Mine disturbance area, Sage grouse winter use area, mule deer summer use area, mule deer staging area, mule deer migration route, mule deer winter areas, sage grouse strutting grounds, antelope yearround occurrence. Resolution: Approximately 3 acres. Ground truthed: Yes. Timing: 1977 to 1981 summaries.

Subjective Evaluation of Map: Localized information, can not be used to evaluate effects of oil and gas development located elsewhere in the BRD study area. Information was gathered to evaluate impacts of coal mining.

MAPPING: Type of map: Raptor nest locations: Area covered: same as above. Scale: 1:24,000.

Evaluation: Information mapped: Mine disturbance area, nest locations for 10 species. Ground truthed: Yes.

Subjective Evaluation of Map: Same as above.

MAPPING: Type of Map: Prairie dog distribution and ferret survey areas. Area covered: same as above. Scale: 1:24,000.

Evaluation: Information mapped: Prairie dog town boundaries searched for ferret sign in 1978 and 1979, scattered prairie dog burrows, locations of black-footed ferret skulls found, continuation of prairie dog towns not surveyed, mine disturbance area. Resolution: 5 to 10 acres. Ground truthed: Yes. Timing: Compiled from 1978 and 1979 surveys.

Subjective Evaluation of Map: See above.

MAPPING: Type of map: Mule deer distribution and migration routes. Area Covered: Same as above. Scale: 1:24,000.

Evaluation: See Wildlife Use Map discussed above.

Subjective Evaluation of Map: See above.

Berry 1982, cont.

MAPPING: Type of Map: Antelope winter distribution. Area covered: Same as above. Scale: 1:24,000.

Evaluation: Information mapped: Distribution during 1978-79 (severe winter), distribution during 1980-81 (mild winter), and "typical" winter distribution. Ground truthed: Yes.

Subjective Evaluation of Map: See above.

MAPPING: Type of Map: Sage grouse areas: Area covered: See above. Scale: 1:24,000.

Evaluation: Information mapped: Mine disturbance area, sage grouse strutting grounds, winter areas, brood and activity drive routes. Resolution: Less than 5 acres. Ground truthed: Yes.

Subjective Evaluation of Map: See above.

Berry, J.D., and R.L. Eng. 1979 and 1980; Berry, J.D. 1981.

(1979, 1980, and 1981) Peter Kiewit Sons' Co. sage grouse study, South Haystack, Wyoming. Unpublished reports, Kiewit Mining and Engineering Company, Sheridan, WY. (ANALYZED DATA)

Location: Kiewit Mining and Engineering Co., Sheridan, WY.

Contact: Tom Dahmer.

Evaluation: Design: Lek counts on mine permit area and vicinity for 1979, 1980, and 1981. Sage grouse trapping on leks marking and radio-telemetry birds, especially brood hens. Mortality of marked birds, nest locations and seasonal movements of telemetered birds indicates year to year variability and variation between individuals. Timing: Ongoing. Analysis Methods: Quantitative summaries of sage grouse distances moved from leks to nesting areas, frequency distributions of sage grouse by elevation class, brood drive route summaries by year. Study is replicable. Mapping of relocations per telemetered bird provided each year (scale varies year to year).

Value to OIA Study: Location: Within BRD study area (T16N to T17N and R117W to R118W). Conclusions: Demonstrates importance of areas surrounding leks for nesting and shows annual variation in movement patterns and wintering areas. Since this study area is removed from areas of oil and gas development this information may only serve for comparisons if future studies are conducted elsewhere.

Subjective Evaluation of Documents: Unique information of sage grouse movements within overall BRD study area and points out importance of this kind of data in evaluating the dynamics of a species' annual cycle. The studies' limitations lie in the restricted area surveyed.

Binns, N.A. 1977. Present status of indigenous populations of cutthroat trout, Salmo clarki, in southwest Wyoming. Wyoming Game and Fish Department, Fisheries Technical Bulletin No. 2, Cheyenne, WY. 58pp. (ANALYZED DATA)
Location: WGFD, Cheyenne, WY.

Evaluation: Design: Colorado cutthroat specimens collected, water from cutthroat trout streams analyzed, fish food samples collected, and trout habitat evaluated for streams in the Green River westside tributaries enclave (west of Big Piney) and the Blacks Fork enclave (south of Evanston on Wyoming-Utah boarder). Analysis Methods: Hydrochemical concentrations are averaged for westside tributaries and Blacks Fork streams sampled. No fish food data presented for Blacks Fork tributaries. Stock purity and population characteristics (population status, vitality, fish size and density) are given for the following streams in the Blacks Fork enclave: Little West Fork Blacks Fork River, Muddy Creek, West Fork Muddy Creek, East Fork Muddy Creek, Gilbert Creek, Beaver Dam Hollow Creek, Van Tassel Creek, Horse Creek, and Archie Creek.

Value to OIA Study: Location: Blacks Fork enclave is within the BRD study area. Baseline Data: Information was collected in standard fashion, is repeatable. This data and other information collected on native cutthroats could be combined to define streams known to have been surveyed. Could serve for future comparisons.

Subjective Rating of Document: Valuable for defining streams important to native cutthroat trout.

Binns, N.A. 1981. Bonneville cutthroat trout Salmo clarki utah in Wyoming. Wyoming Game and Fish Department, Fisheries Technical Bulletin No. 5, Cheyenne, WY. (ANALYZED DATA)
Location: WGFD, Cheyenne, WY.

Evaluation: Design: Bonneville cutthroat trout specimens were collected from the Thomas Fork and Smiths Fork drainages. Invertebrate samples were collected and water quality conditions evaluated. Stream Habitat Quality Indices were evaluated at 22 stations within this study area. Additional information on stream flows, stream gradients, elevations, lengths and drainages were also measured. Stream characteristics are given (maximum temperature, drainage area, stream length, average annual flow) for each Habitat Quality monitoring station and trout Habitat Units are provided for 21 stations. A management plan for Bear River cutthroat trout includes maintenance of a monitoring program, habitat improvements, obtaining fisherman use and harvest data on these trout streams, recommendations for future introductions and developing brood stocks, evaluation of additional streams, future development of beaver ponds where appropriate.

Value to OIA Study: Location: Outside of BRD study area. Management plans useful for streams within the study area though. Further study: Habitat Quality Indices need to be developed for streams currently impacted by oil and gas development. Baseline data: This study serves to

Binns 1981, cont.

identify sensitive areas to be considered in future development.

Subjective Evaluation of Document: Although the study was conducted outside of the BRD, it could serve as a comparison for future studies.

Bone, T.L. 1973. The impact of artificial nesting structures on the production and distribution of Canada geese. Unpubl. M.S. Thesis, University of Wyoming, Laramie, WY. (ANALYZED DATA)
 Location: University of Wyoming, Laramie, Science Library.
 Evaluation: Design: Part of a six year study to evaluate various nesting structures on Canada goose production on the Bear River. Three treatment areas, two south of Cokeville and one north of Cokeville. Maps of nesting structure locations on each of the three study units. 1971-1972 comparisons of unit with variety of nesting structures, unit with no structures, and unit with nesting structures present since 1967 which were removed in 1970. Analysis Methods: Productivity data for different nesting structures and for ground nests, qualitative comparisons of treatments and study units.
 Value to OIA Study: Location: In vicinity of BRD study area although further north than primary area of interest.
 Conclusions: Goose production in 1971 was increased 200% by the utilization of structures. Where structures were removed, goose production dropped. Flooding and nest predation cited as factors in low ground nest productivity.
 Subjective Evaluation of Document: Supplements other nesting structure studies and verifies the importance of structures for increasing productivity in marginal habitats or habitats subject to destruction of ground nests. Suggestion for use in future mitigation/enhancement projects.

Campbell, T.M., T.W. Clark, and G.R. Groves. 1982. First record of pygmy rabbits (Brachylagus idahoensis) in Wyoming. Great Basin Naturalist 42: 100. (ANALYZED DATA)

Location: Published literature.

Evaluation: Design: Collection of pygmy rabbit specimens east of Carter, WY and on Cumberland Flats, both in Uinta County, WY. Species previously reported from Bannock County, ID and Cache County, UT. Species presumed to be rare in Wyoming. Timing: Ongoing or future studies to determine distribution, habitat relationships and taxonomic status.

Value to OIA Study: Location: Occurrence within BRD study area and documentation that species does occur beyond previously documented range.

Subjective Evaluation of Document: Little importance except to suggest inventories of species in future studies.

Clark, T.W. 1977. Preliminary mammal survey of Fossil Butte National Monument, Wyoming. Great Basin Naturalist 37: 91-94. (ANALYZED DATA)

Location: Published Literature.

Evaluation: Design: Mammals were observed by direct observation or their sign, small mammals were snap-trapped in each of six plant communities. Only least chipmunks and deer mice were snap-trapped. In all, 23 species of mammals were observed. Methods of analysis: Species were listed by plant community in which they were observed.

Value to OIA Study: Conclusions: Livestock grazing in meadows and willow-aspen communities (exacerbated by salt block placement in these areas) has possible adverse impacts on the small mammal community: species expected to occur in these plant communities were not collected or observed. Location: The study was done just north of the BRD study area. Further study: The implications of livestock grazing effects on native mammalian fauna needs to be closely examined at Fossil Buttes as well as throughout the BRD study area.

Subjective Evaluation of Document: Limited value since species densities, population levels, and quantitative evaluations of habitat associations are not provided. The study does complement other mammal inventories conducted elsewhere in the BRD study area.

Clark, T.W., and T.M. Campbell. 1980. Black-footed ferret survey along U.S. Highway 189, Kemmerer to Lazeart Junction, Wyoming. Unpublished report to Wyoming Highway Department, Cheyenne, WY.. (ANALYZED DATA)

Location: Wyoming Highway Department, State Office, Cheyenne, WY. Contact: William King.

Evaluation: Design: Search of a 2 mile wide (one mile each side) corridor on US 189 from Kemmerer to I-80 for black-footed ferret occurrence. All prairie dog colonies within this strip as well as some colonies outside were initially identified from an aerial survey. All colonies were searched on foot and from a vehicle during day and night (spotlight) searches. A total of 63 colonies were examined. Analysis methods: Quantitative evaluation of acreage covered in survey, number of colonies surveyed with mean, range and total acreage surveyed. Also gives town specific acreage, number of burrow openings, burrow density, badger activity, estimated total prairie dog populations and specific town priorities for future searches.

Value to OIA Study: Location: The area searched lies within the eastern portion of the BRD study area. Conclusions: No evidence of ferrets was discovered. This study adds to other prairie dog town inventories (eg. Martin and Schroeder 1979 and 1980) conducted in BRD area.

Subjective Evaluation of Document: Valueable as additional prairie dog information as well as badger activity in area.

MAPPING: Type of Map: Prairie dog town distribution. Area covered:

Clark and Campbell 1980, cont.

see above. Scale: $\frac{1}{2}$ " to one mile and 1:24,000. Resolution: less than one acre.

Evaluation: Prairie dog towns are numbered and corresponding references on town characteristics are given in the text.
Subjective Evaluation of Map: Adds to other mapped prairie dog town mapped information.

Clark, T.W., and R.D. Dorn. 1981. Rare and endangered vascular plants and vertebrates of Wyoming. The Nature Conservancy, Wyoming Natural Heritage Program, Cheyenne, WY. 66pp.
(ANALYZED DATA)

Location: Wyoming Natural Heritage Program, Cheyenne, WY.
Contact: Robert Lichvar.

Evaluation: Design: Citations of endangered, threatened, unique, rare, and undetermined status (insufficient information) designations for various Wyoming wildlife and plant species. For threatened and endangered species the following information is provided: distinguishing characteristics, habitat preferences, present distribution, former distribution, reasons for decline, legal status, remarks and references. Rare, unique, and species of undetermined status are either listed or known range of occurrence provided.

Value to OIA Study: Provides a catalog of species (especially rare, unique, or status undetermined categories) likely to occur in the BRD study area but for the most part does not give actual documentation of their observation.

Subjective Evaluation of Document: Little value except to suggest the possibility of species' occurrence in study area.

Cochrane, J.F., and R. Oakleaf. 1982. Long-billed curlew survey evaluations with notes on distribution, abundance, and habitat use in Wyoming. Unpublished Special Project Report (AP1 Project), Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: Design: Compilation of historical sightings (in Cokeville area), general habitat descriptions of known extant nesting areas, primarily in the Upper Green River valley. No surveys conducted in BRD study area.

Value to OIA Study: Documents historical occurrence of species in study area. Otherwise limited usefulness unless suitable habitat is documented, especially in upper Bear River region.

Subjective Rating of Document: Very little value since no surveys were conducted in study area. May eventually serve for comparisons of nesting habitats if nests are found within study area. Observations from other sources document long-billed curlews within the study area although there are no records (recent) of nesting.

DePuit, E.J., and C.P. Waldvogel. 1981. Study plan: plant community successional status and processes on abandoned oil and gas exploration sites within the overthrust belt of western Wyoming. Unpublished proposal to U.S. Forest Service, Intermountain Forest and Range Experiment Station, Logan, Utah. (MISCELLANEOUS DOCUMENT)

Location: University of Wyoming, Laramie.

Contact: Edward DePuit.

Evaluation: Design: Identification and characterization of past drill sites and their associated vegetational successional stages when no treatments have been applied compared to known revegetation attempts or where some other treatment has been attempted. The study also examines the interactions of time since disturbance, elevation/climate, topography, soil/substrate, life zone, and land use practices as they relate to plant establishment. Timing: Ongoing through 1983, one field season is already completed but data are presently unavailable.

Value to OIA Study: When the results of this study are known they may be applied to conditions within the BRD study area with respect to drill pad revegetation practices. There are several habitat types being sampled in this study that have analogous features to well sites or potential well sites within the BRD area even though the study is being conducted within the Bridger-Teton National Forest.

Subjective Evaluation of Document: The Document per se has no value since no data are presented. The study itself is potentially very valuable once completed.

Dorn, J.L. 1978. Wyoming ornithology. Bureau of Land Management and Wyoming Game and Fish Department contract YA-512-CT8-126. Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne or BLM, Cheyenne, WY.

Evaluation: Design: Bibliography of published and unpublished accounts of birds, by species and in general, in Wyoming. Index to species and Wyoming area index (see Southwest), abstracts to selected references and historical accounts. Tables include densities of bird species by BLM vegetation types and population growth predictions based on published literature.

Value to OIA Study: Little value, no accounts found in study area. Density estimates might provide comparisons for future BRD studies.

Subjective Evaluation of Document: No use for evaluation of current and future impacts.

Dunning, G. 1974. Inventory of stream channel alterations by aerial surveillance of the Green River and Bear River drainages. Project 4074-07-6301. Unpublished administrative report, Fish Division, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: Design: Channel alteration sites were investigated from the air and photographed,. Distances of channel damagae and alterations were measured on 7.5' quads. Bank erosion and streamside vegetation were qualitatively defined. Some areas of known alteration were not detected from the air. Direct management implications are defined.

Value to OIA Study: Location: Portions of the following drainages were included in this study: Hams Fork from Lake Viva Naughton to Opal, Bear River from Utah State line to Wookruff Reservoir (Uinta County) and near Cokeville (Lincoln County), Smiths Fork north of Cokeville (Lincoln County). Conclusions: The survey points out what not to do in initiating stream alterations since many were detrimental to both fish populations (especially trout) as well as landowners. Bank sloping and oxbow cuts were recognized as most frequent of alterations as well as most destructive of trout habitat. Further study: The survey, now 8 years old, should be repeated and expanded to include additional tributaries known to contain trout populations. Future mitigative measures could include channel improvements on deteriorated stretches.

Subjective Evaluation of Document: Since legal descriptions of observed channel alterations are provided the study is repeatable even though the effects of alteration projects are qualitative. The suvey points out the need for public awareness of proper stream alteration techniques.

Findholt, S., R. Oakleaf, and B. Long. 1981. Working draft of Wyoming mammal atlas. Wyoming Game and Fish Department, Game Division, Cheyenne, WY. 25pp. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: Design: Documented occurrence of mammalian species by degree blocks (Latilongs) within Wyoming. BRD study area falls within degree block 22 (Fort Bridger). For each species occurring within degree block 22, the occurrence is noted as historical (pre-1965), recent, whether breeding is assumed or not, if a specimen or photograph is available, and general habitats, life form category, seasonal status, and abundance are noted. Timing: Updated when new information is available.

Value to OIA Study: Location: The area covered by degree block 22 is too broad to serve as baseline data. Species listed for this degree block provide an indication of what might be expected to occur within the study area.

Subjective Evaluation of Document: Not useful as baseline information but provides a list of species likely to occur in study area.

Finn, L., and R. Rothwell. 1977. Prairie dog town survey.
 Filed data sheets, Wyoming Game and Fish Department, Green
 River District Office, Green River, WY. (RAW DATA)
 Location: WGFD, Green River, WY.
 Contact: Elaine Raper.

Evaluation: Design: White-tailed prairie dog towns within
 T16N to T19N and R116W to R118W were surveyed on the ground.
 Data includes town location, number of holes per acre,
 acreage of the town, general vegetation cover in town
 vicinity, numbers of prairie dogs, black-footed ferret sign,
 burrowing owls, and other predator sign. Timing: Data
 collected in 1977, no other follow-up surveys were noted.

Value To OIA Study: Location: Although some of the towns
 surveyed are east of the BRD study area, towns are within
 the study area. Further study: This information needs to
 be combined with USFWS prairie dog town surveys done in
 the study area to determine overlap or complementation.
 A map of combined surveys could be produced denoting
 inventoried information.

Subjective Evaluation of Data: Should be useful in documenting
 locations of known towns and areas previously surveyed.

Fitton, S. 1982. Maps, tables and appendix from draft report:
 birds found nesting in Utah juniper communities in Wyoming.
 Unpublished draft figures and tables, Wyoming Game and Fish
 Department, Lander, WY. (RAW DATA)
 Location: WGFD, Lander, WY.

Contact: Robert Oakleaf or Sam Fitton.

Evaluation: Design: Observation sites and reconnaissance routes
 for breeding bird occurrence in Utah juniper communities
 located throughout Wyoming. Ten species are listed as
 juniper dependent. In degree block 22 (BRD study area is
 within this block) the gray flycatcher, Bewick's wren,
 and black-throated gray warbler were documented in juniper
 communities and are listed as juniper dependent species.

Value to OIA Study: Location: No observations were conducted
 within BRD area juniper communities. Conclusions: Data
 tables point out importance of Utah juniper communities
 to certain passerine species. Further study: BRD juniper
 communities need to be examined.

Subjective Evaluation of Data: Not use ful as baseline information
 but data show variation between juniper communities and
 passerine inhabitants within Wyoming and demonstrate unique
 bird fauna associated with these limited habitats.

Gdara, A.O. 1977. Interpretation of long term vegetation data from permanent quadrats on semiarid shrublands of western Wyoming. Unpublished M.S. Thesis, University of Wyoming, Laramie. 114pp. (ANALYZED DATA)
 Location: University of Wyoming, Laramie, Science Library.
 Evaluation: Design: Four exclosures established in 1963 on the Bear River Divide and Cumberland Flats were given various treatments (sagebrush spraying, no treatment) in 1963 and evaluated in 1976. Generally grasses increased inside the exclosures, especially on sprayed areas. One exclosure received no treatment and grasses increased inside, compared to outside the exclosure. Analysis; Comparisons of sprayed and non-sprayed areas from samples collected inside and outside exclosure. Significant differences determined using 90% confidence intervals.
 Value to OIA Study: Location: Within BRD study area. Conclusions: Livestock grazing alters vegetation cover; sagebrush spraying contributes to higher grass production, especially when grazing can be restricted. Further study: The exclosures are continued to be monitored although data since 1976 are not available.
 Subjective Evaluation of Document: Good experimental design and only record of long term vegetation changes found for BRD study area. However, only four sites were examined within study area and inferences cannot be made on grazing effects on study area as a whole.

Hoak, J.H., J.L. Weaver, and T.W. Clark. 1982. Wolverines in western Wyoming. Northwest Science (in press).
 (ANALYZED DATA)
 Location: Jackson, WY.
 Contact: Tim W. Clark.
 Evaluation: Design: Compilation of wolverine sightings in Bridger-Teton National Forest vicinity.
 Value to OIA Study: Location: Sightings in Cokeville Ranger District of BTNF. Suggests possible wolverine occurrence just north of the BRD study area.
 Subjective Evaluation of Document: Adds to anecdotal information for species occurrence (wolverines are listed as rare by WGFD) although reported sightings are outside of study area.

Hollings, M., and J. Berry. 1980. Standing water and wetlands coal unsuitability study, Kemmerer Known Recoverable Coal Resource Area. Bureau of Land Management, Rock Springs District, Rock Springs, WY. (ANALYZED DATA)
 Location: BLM, Rock Springs, WY.
 Contact: Bruce Smith.
 Evaluation: Design: 299 ponds on public land or with Federal mineral rights were surveyed in summer 1980 for hydrochemistry, size, shape, depth and water duration. Additional information

Hollings and Berry 1980, cont.

on riparian and aquatic vegetation and observed wildlife and livestock was also obtained. Derived variables on wildlife habitat potentials for big game, furbearers, livestock, waterfowl, non-waterfowl birds, and fisheries are presented. Habitat potential is listed as good, fair, or poor for each pond. Analysis: Detailed accounts of data compilation techniques are provided for each category of wildlife habitat ratings. Replicability: Survey is repeatable. Additional information: Field maps of each pond, aquatic and riparian vegetation species list, Wildlife species occurrence by pond.

Value to OIA Study: Location: On Cumberland flats, extending north of Kemmerer and south of I-80. Conclusions: Relative importance of different size ponds to the different classes of wildlife listed above. Further Study: Should be expanded to include ponds on private land and areas outside of the coal resource area. Valuable for wildlife management and for future comparisons of ponds in BRD study area.

Subjective Evaluation of Document: Not useful for baseline data in assessments for oil and gas developments but points out needs for continuation of standing waters inventories and importance of ponds to wildlife species.

Innis, G.S. 1978. Reconstruction of ecosystems in arid lands.

Unpublished proposal to NSF, Ecosystem Studies Program, Utah State University, Logan, UT. (MISCELLANEOUS DOCUMENT)

Location: Utah State University, Logan, UT.

Contact: James A. MacMahon.

Evaluation: Design: Identification and development of basic scientific principles on the reconstruction of ecosystems on disturbed lands. Research being done on reclaimed coal mine lands at the Kemmerer Coal Co. mine south of Kemmerer. Proposed projects include: 1) Vegetation planting and subsequent dynamics of shrubs, 2) description and analyses of developmental processes associated with arid region plant communities follow severe perturbations, 3) seed-rain on disturbed sites, 4) ecological tolerance determined through greenhouse studies of vegetation species competition, 5) initial plantings of shrubs and effects of stressors on plant development, 6) plant architecture and guild and soil invertebrate species density, 7) above ground plant dwelling invertebrates and lizards, birds and mammals densities, 8) soil microbiology following disturbances and treatments, 9) soils chemical and physical parameters, 10) meteorological parameters (radiation exchange, wind speed and direction, humidity, temperature, and precipitation) interacting with other parameters, and 10) modelling of the ecosystem.

Value to OIA Study: When the results of these studies are known they should be of great value to efforts at reclamation and revegetation within the BRD study area. The

Innis 1978, cont.

study is to be ongoing for 3 years . Location: The study is within the BRD study area, although conditions experienced with mined soils may not correspond to those associated with recontoured soils at drill pads and access roads.

Subjective Evaluation of Document: the document per se has no value since no data are presented. The study results will be very valuable once they are available.

Innis, G.S., and J.A. MacMahon. 1982. Interim report to the Pittsburg and Midway Coal Mining Co. covering progress through 1981. Unpublished report, Utah State University, Logan, UT. (ANALYZED DATA)

Location: Utah State University, Logan, UT.

Contact: James A MacMahon.

Evaluation: Design: Description of research activities on Kemmerer Coal mine (P&M Coal Co.) ecosystem reconstruction project. Data collected but not analyzed. Studies reported in progress include: seed trapping, soil sampling, annual forb densities under shrubs and between shrubs, grass seed plantings undershrubs and in between shrubs with some planting sites protected by exclosures to determine rodent granivory; feeding trials using six native shrub and grass species' seeds to diurnal and nocturnal vertebrates and ants; shrub removal effects on rodent populations.

Value to OIA Study: Conclusions: In the feeding trials, the vertebrate species show species specific seed preferences.

Shrub removal only effected Eutamias; they moved out of the treatment plot. Microtus montanus showed a slight increase on the treatment plot. Shrub removal may not affect nocturnal species in the short term. Further study: These and other studies related to vegetation, soil, meteorology, and below-ground microbiology are continuing. Results should be of practical application to revegetation efforts on other disturbed lands.

Subjective Evaluation of Document: No data is given, only gross summaries of projects.

Jenkins, M.A. 1979 and 1980. Peregrine falcon (Falco peregrinus) essential habitat on and near Bureau of Land Management lands in Wyoming. Unpublished annual reports, U.S. Fish and Wildlife Service, Denver Wildlife Research Center, Denver, CO. (ANALYZED DATA)

Location: USFWS, Denver Wildlife Research Center, Denver, Co

Contact: M. Alan Jenkins.

Evaluation: Objectives: Determine distributions and status of nesting and wintering peregrine falcons, describe habitat used, and determine essential elements of the habitat of peregrine falcons on and near BLM land in Wyoming.

Design: Search for historical records of peregrine sightings, aerial and ground searches of potential peregrine nesting habitats. Locations of peregrine falcon sign or sightings

Jenkins 1979 and 1980, cont.

and historical sighting locations are restricted information and were not included in these documents.

Value to OIA Study: Location: 1979 surveys in Lincoln and Uinta Counties, along the Green River and western Sweetwater County. 1980 surveys conducted along the Green River only.

Subjective Evaluation of Document: Interested parties must contact Dr. Jenkins for specific information on peregrine occurrence on or near the BRD study area; these two documents only provide survey areas, field methods and background information.

Jenkins, M.A. 1982. Bald eagle (Haliaeetus leucocephalus) essential habitat on and near Bureau of Land Management (BLM) lands in Wyoming. Unpublished draft report for FY 1981 and 1982, U.S. Fish and Wildlife Service, Denver Wildlife Research Center, Denver, CO. (ANALYZED DATA)
Location: USFWS, Denver Wildlife Research Center, Denver, CO.
Contact: M. Alan Jenkins.

Evaluation: Design: Examination of winter roosting at Woodruff Narrows. Ground counts at roost were conducted at least twice a month, individual eagles were radio telemetered and movements within the study area determined, spring migration of telemetered eagles was followed, food habits (castings collected beneath roost trees) examined, and behavioral response to disturbances documented. Analysis methods: Quantitative evaluations of roost counts (November 1980 to March 1982), age ratios (and comparisons with other studies in Wyoming and U.S.), daytime behaviors of eagles, food habit analyses, responses to various disturbance stimuli, and use of different habitat types surrounding the study area.

Value to OIA Study: Location: Within BRD study area. Repeatability: All aspects of the study are replicable. Conclusions: The Woodruff Narrows roost is extremely important to wintering bald eagles, disruption of the roosting area and declines of prey items (especially deer and livestock carrion) could have severe consequences on the population.

Further study: Although the USFWS study has terminated, the study plan should be continued and expanded to include the Rock Creek roost, east of Fossil Butte National Monument.

Subjective Evaluation of Document: Extremely valuable information and could be used as baseline data in the event of further industrial development in the BRD study area.

Julian, T.D.. 1969. Elk on Commissary Ridge, western Wyoming. Unpublished M.S. Thesis, University of Wyoming, Laramie, WY. 75pp. (ANALYZED DATA)

Location: University of Wyoming, Laramie, Science Library.

Evaluation: Design: Areas of elk concentrations on Commissary Ridge were located and elk migrations followed. These areas were examined for intensity and seasonal use, competition with livestock, and disturbance related to elk use. Migration to winter range by unmarked elk, qualitative (subjective) evaluation of browse conditions and livestock competition, and quantitative evaluation of soils characteristics are presented. Analysis methods: For the most part only qualitative descriptions of elk movements and range use (and overuse) are provided. Repeatability: Since no specific locations of elk range evaluations are given it would be difficult to repeat the study. General area maps are provided showing summer and winter concentrations of elk and counts are summarized for these areas but no specific distribution data are presented.

Value to OIA Study: Location: This study area is north of the BRD area but it seems likely (from other elk studies) that some of these elk migrate into the BRD during severe winters. Conclusions: Elk seasonal distributions are based on one year's survey and range use and migration patterns may change from year to year as functions of any number of factors.

Subjective Evaluation of Document: Limited value to OIA study due to location and to subjective nature of the study. Could not be used as baseline (pre-development) information except on the grossest level: Not a long term documentation of elk biology.

Julian, T.D. 1970. Browse study - Rock Creek Ridge, upper Leige Creek, Underwood Canyon. Filed data sheets, Wyoming Game and Fish Department, Green River District Office, Green River, WY. (RAW DATA)

Location: WGFD, Green River, WY.

Contact: Elaine Raper.

Evaluation: Design: Transects established on areas north of BRD study area (see title). Browse use of mountain mahogeny and serviceberry characterized by form class, plant age class, and per cent leader use. No methods are given, must assume that methods in WGFD Handbook of Biologicla Techniques were employed. Analysis methods: summaries of data by transect and raw data are available. No specific locations of transects are provided.

Value to OIA Study: Locations: North of BRD study area. Repeatability: Since no locations were reported except by broad geographical area, and techniques used must be inferred, exact replicability is not possible.

Subjective Evaluation of Data: Limited value, if any, as baseline information.

Julian, T.D. 1969. Aerial antelope trend count, District IV.
 1970. Elk, deer, and sheep population studies; forage utilization studies.
 1971 to 1974. Antelope, deer, elk, moose, and sheep population studies; forage utilization studies.

Unpublished spot reports, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, Wy.

Evaluation: Design: Variety of information : 1969: antelope aerial counts in Lincoln and Uinta Counties, 1959 to 1969 count summaries and changes, numbers counted in 1969 plotted on large scale (1:500,000 approx.) map; 1970: herd composition counts in Lincoln County and Uinta County, no distributions, browse transects on BRD (general geographic locations given) with per cent use per transect (leader use), pellet group counts for deer, cow, and sheep on same transects; 1971: harvest data, deer tagging near Leroy, browse transects in Lincoln County only; 1972 -1974: Herd compositions, some population trend counts, some harvest data, deer tagging and recovered deer locations (1974), BRD browse transects and pellet group counts (1972,1973), deer age determination by tooth analysis of harvested animals (1972), antelope counts mapped (1973). Analysis methods: Data are summarized by county.

Value to OIA Study: Location: BRD study area is within Uinta and Lincoln Counties but summarized data provide no baseline for counts done within study area (no study area specific data are presented). Browse transects and associated pellet group surveys are provided as summary data, no variance measures provided nor are transect locations specified beyond general geographic area. Unlikely that information and study could be replicated for baseline/development period comparisons. Deer tagging data needs to be compiled for all tagging studies and combined with re-observations and hunter tag return locations for general movement analysis.

Subjective Evaluation of Documents: Very little value as baseline data because of large area summaries and general locations of browse and pellet group surveys. Without actual sampled data cannot examine yearly variation of parameters measure to see if significant differences exist. Deer tagging data is probably the most useful information in these documents.

Julian, T.D. 1973 to 1975. Deer tagging data on Crawford Mountains. Filed data sheets, Wyoming Game and Fish Department, Green River District Office, Green River, Wyoming. (RAW DATA)
 Location: WGFD, Green River, WY.

Contact: Elaine Raper.

Evaluation: Tagging dates, tag numbers, and sex of deer tagged. No specific locations nor types of traps used.

Value to OIA Study: This data needs to be compiled with other deer tagging studies and coordinated with hunter tag returns so that gross movements from trap sites to harvest locations can be mapped.

Note: some of this information is included in Julian 1973 and 1974, see above.

June, J.W. 1976, 1977, 1978, 1979, 1980, and 1981. Antelope population investigations, Uinta-Cedar Mountain DAU. Unpublished job completion reports for 1975 to 1980, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: The following information types are included in these job completion reports. Years for which the specific information is available are in parenthesis. Antelope pre-hunt season herd classifications (1981, 1980, 1979, 1978, 1977, 1976) broken down by hunt area (1981 to 1976); Antelope post-hunt season herd classifications (1976 only); Antelope herd trend counts (1981 only), Hunter check station or field check harvest age structure (1981, 1980, 1979, 1978, 1977, and 1976); Harvest survey questionnaire results yielding hunter percent success, Days per animal taken and hunter days spent (broken down by hunt area 1981, 1980, 1979, 1978, 1977, 1976); estimates for post-season populations and following year pre-season population projections are also provided in each report. Analysis methods: All count data and harvest data are summarized for entire DAU or by hunt area with the exception of 1981 trend counts which are mapped by counting blocks (smallest block approximately 115 sq.mi.) within the DAU.

Value to OIA Study: Location: The western portion of the Uinta-Cedar Mountain DAU extends to the eastern Utah boarder south of I-80. With data summarized by hunt area or by DAU it is impossible to discern antelope population levels within the southern portion of the BRD study area. The same can be said of harvest data.

Subjective Evaluation of Documents: This information is too gross to be useful in impact evaluation.

June, J.W. 1976, 1977, 1978, 1979, 1980, 1981 and 1982. Mule deer populaton investigations, Uinta-Cedar Mountain DAU. Unpublished job completion reports for 1975 to 1981. Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: The following information types are included in these job completion reports. Years for which the specific information is available are in parenthesis. Mule deer pre-hunt sex/age classification (none); post-hunt season sex/age classifications (1976, 1978, 1980, 1981, 1982); population trend counts (none); harvest survey questionnaire results yielding hunter percent success, days per animal taken and hunter days spent (broken down by hunt area 1976, 1977, 1978, 1979, 1980, 1981, 1982); hunter field check data (1976 to 1982); age structure of harvest (1977, 1980, 1981, 1982); Road kills/illegal harvest listed (1979-1982); estimates for post-season populations and following year pre-season population projections are also provided in each report. Analysis methods: All count data, when available, and harvest data are summarized for the entire DAU or by hunt area. No area specific distributions or count information

June 1976 to 1982, cont.

is available.

Value to OIA Study: Location: The western portion of the Uinta-Cedar Mountain DAU extends to the eastern Utah boarder south of I-80. With data summarized by hunt area or by entire DAU it is impossible to discern mule deer population levels or distribution within the southern portion of the BRD study area. This is also the case with harvest data. The author does point out that there is movement of deer in and out of Utah but no tagging studies have been done to elaborate on this.

Subjective Evaluation of Documents: These data, when provided, are not specific to geographic areas of concern and can not be used for impact assessment.

June, J.W. 1976, 1977, 1978, 1979, 1980, 1981. Elk population investigations, Uinta-Cedar Mountain DAU. Unpublished job completion reports for 1975 to 1980. Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: The following information types are included in these job completion reports. Years for which the specific information is available are in parenthesis. Elk pre-hunt sex/age classification (none); post-hunt sex/age classification (1976,1978,1979,1980); population trends counts (1976,1978, 1979, 1980); harvest survey questionnaire results yielding hunter percent success, days per animal taken and hunter days spent (broken down by hunt area 1976, 1977, 1978,1979, 1980, 1981); hunter field check data (1978, 1979, 1980,1981); Age structure of harvest (none); no illegal mortality reported. Also, estimates for post-season populations and following year pre-season population projections are provided in each report. Graphs of trend counts (1968 to 1980) and post season classifications are given in the 1981 report. Analysis methods: All count data and harvest data are summarized for the entire DAU or by hunt area. No area specific distributions or count information are available.

Value to OIA Study: Location: The western portion of the Uinta-Cedar Mountain DAU extends to the eastern Utah boarder south of I-80. With data summarized by hunt area or by DAU it is impossible to discern elk population levels or distribution within the southern portion of the BRD study area. This is also the case with harvest data. The author does point out that there is movement of elk in and out of Utah but no tagging studies have been conducted to elaborate on movement.

Subjective Evaluation of Documents: These data are not specific to geographic areas of concern and can not be used for impact assessment.

June, J.W. 1976, 1977, 1978, 1979, 1980, 1981. Moose population investigations, Uinta-Cedar Mountain DAU. Unpublished job completion reports for 1975 to 1980. Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.
Evaluation: The following information types are included in these job completion reports. Years for which the specific information is available are in parenthesis. Moose pre-hunt sex/age classification (none); post-hunt sex/age classifications (1976 to 1980); population trend counts (1976 to 1980); harvest survey questionnaire results yielding hunter percent success, days per animal taken, and hunting days (1976 to 1981); hunter field check data (1978, 1979, 1980, 1981); age structure of harvest (1978, 1979); road kills/illegal harvest listed (1979 only). Estimates of post-season populations and following year pre-season population projections are also provided in each report. Analysis methods: All count data and harvest data are summarized by hunt area or for the entire DAU. No area specific information is presented.

Value to OIA Study: Location: The western portion of the Uinta-Cedar Mountain DAU extends to the eastern Utah boarder south of I-80. With data summarized by hunt area or by DAU it is impossible to discern moose population levels or distribution within the southern portion of the BRD study area. This is also the case with harvest information. The author does point out that there is movement of moose in and out of Utah but no tagging studies have been conducted to elaborate on movement.

Subjective Evaluation of Documents: These data are not specific to the geographic areas of concern and can not be used for impact assessment.

June, J.W. 1976, 1977. Lockman, D.C. 1978. Roy, D.R. 1979, 1980, 1981. Antelope population investigations, Carter Lease DAU. Unpublished job completion reports for 1975 to 1980. Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.
Evaluation: The following information types are included in these job completion reports. Years for which the information is provided are in parenthesis. Antelope pre-hunt sex/age classification (1976 to 1981); post-hunt sex/age classifications (none); population trend count (by geographic area 1978, 1980); harvest questionnaire results yielding hunter percent success, days per animal taken, and hunter days spent (broken down by hunt area 1976 to 1981); hunter field check data (1977, 1980); harvest age structure (1977, 1978, 1979, 1980, 1981); road kill/illegal harvest records (1978, 1979, 1980, 1981). Estimates for post-season populations and following year pre-season population projections are also provided in each report. Analysis: Some count data has been recorded by geographic area (eg. west side of BRD, 1978) but most of this information is presented as summary data for the DAU

June 1976, 1977, Lockman 1978, Roy 1979 to 1981, cont.

or by hunt area. Only trend count data in 1978 and 1980 gives geographic locations of counts. No other distribution information is available.

Value to OIA Study: Location: the Carter Lease covers the majority of the BRD study area and more land to the east of US 189. With data summarized by hunt area or DAU it is not possible to discern any antelope distributions from year to year within the BRD study area.

Subjective Evaluation of Documents: These reports provide large scale information but nothing specific enough to evaluate impacts within a particular area of concern.

June, J.W. 1976, 1977. Lockman, D.C. 1978. Roy, D.R. 1979, 1980, 1981. Hays, D. 1982. Mule deer population investigations, Carter Lease DAU. Unpublished job completion reports for 1975 to 1981. Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: The following information types are included in these job completion reports. Years for which the information is available are in parenthesis: Mule deer pre-hunt sex/age composition (none); post-hut season sex/age composition (1976 to 1982); no population trend counts; harvest questionnaire results yielding hunter percent success, days per animal taken and hunter days spent (1976 to 1982); hunter field check data (1976, 1978 to 1982); age structure of harvest (1978 to 1982); road kill/illegal harvest/cripple loss records (1976, 1978, 1980, 1981, 1982). Estimates for post-season populations and following year pre-season population projections are also provided in each report. The 1978 and 1979 reports provide the same list of mule deer captured and tagged in the South Haystack area (also see Monarch 1977). In 1981, the northwest portion of the Carter Lease DAU was transferred to the Wyoming Range Mule Deer DAU (see Lockman 1981). Apparently deer have been moving from the northwest Carter Lease to adjacent areas in the former West Green River DAU by crossing highway US 30. The movement is pronounced during winters. Analysis methods: Counts are summarized for either the entire DAU or by general geographic area (eg. east of the BRD or west of the BRD).

Value to OIA Study: Location: the western portion of the Carter Lease DAU encompasses most of the BRD study area. Within this western portion lies designated critical mule deer winter range. However, no specific distribution data is given for deer on this winter range or anywhere else on the DAU.

Subjective Evaluation of Documents: These reports provide large scale population information representing one or two counts within a given year. There are no data specific to any of the impacted areas either before or during the impacts that could be used for assessment of industry activities effects on mule deer.

June, J.W. 1976, 1977. Lockman, D.C. 1978. Roy, D.R. 1979, 1980, 1981. Elk population investigations, Carter Lease DAU. Unpublished job completion reports for 1975 to 1980, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)
Location: WGFD, Cheyenne, WY.

Evaluation: The following information types are included in these job completion reports. Years for which the information is available are in parenthesis. Elk pre-hunt sex/age composition (none); post-hunt sex/age composition (none); population trend counts (none); harvest questionnaire (1976 to 1978); hunter field check data (1981); harvest age structure data (none); illegal and road kills (1980); estimates for post-season populations and following year pre-season population projections are also provided in each report. Analysis methods: none, no count data has been obtained for elk in this DAU.

Value to OIA study: Location: The western portion of the Carter Lease DAU encompasses most of the BRD study area. From these reports it is apparent that little, if anything, is known about elk in the BRD study area.

Subjective Evaluation of Documents: The only value of these reports is to emphasize the lack of information on elk occurrence in the BRD study area.

June, J.W. 1976, 1977. Lockman, D.C. 1978. Roy, D.R. 1979, 1980, 1981. Moose population investigations, Carter Lease DAU. Unpublished job completion reports for 1975 to 1980, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)
Location: WGFD, Cheyenne, WY.

Evaluation: The following information types are included in these job completion reports. Years for which the information is available are in parenthesis: Moose pre-hunt season sex/age composition (none); post-hunt season sex/age composition (1976, 1977); population trend count (1976, 1977); harvest questionnaire results yielding hunter percent success, days per animal taken, and hunter days spent (1976 to 1981); hunter field check data (1978, 1980, 1981); harvest age structure (1978, 1980, 1981); illegal/road kill records (1978). Estimates for post-season population levels and following year pre-season population projections are also provided in each report. Analysis methods: When counts were made, they are summarized for the entire DAU.

Value to OIA Study: Location: The western portion of the Carter Lease DAU encompasses most of the BRD study area. From these reports it is apparent that very little information is available for moose in the BRD study area.

Subjective Evaluation of Documents: The count data, summarized by DAU, is not continuous from one year to the next. The level of resolution of this information is too gross to be useful for impact evaluation.

June, J.W. 1976, Lockman, D.C., and J.W. June. 1977. Lockman, D.C. 1978. Roy, D.R. 1979, 1980, 1981. Moose population investigations West Green River DAU. Unpublished job completion reports for 1975 to 1980, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: The following information is presented:

Pre-hunt season sex/age composition counts for 1977 only; harvest questionnaire results for 1978 only; harvest age structure for 1978 only. Estimates for pre-season population levels and following year post-season population projections are given in each report although there have been no population counts conducted on this DAU.

Value to OIA Study: Location: The West Green River moose DAU lies north and east of the BRD study area. There is little, if any, information available on this moose population.

Subjective Evaluation of Documents: No information is available for moose in this area. The documents point to the need for further study should this area be subject to future oil and gas development.

June, J.W. 1977 - 1980. Breeding bird Survey, Cumberland Route 022.

June, J.W., and D. Hays. 1977 - 1982. Breeding bird Survey, Diamondville-Carter Route 092.

Filed data sheets, Wyoming Game and Fish Department, Green River District Office, Green River, WY. (RAW DATA)

Location: WGFD, Green River, WY.

Contact: Elaine Raper.

Evaluation: Design: Standard breeding bird survey roadside counts. Data sheets provide location of each stop on the given route with counts of each species per stop, total counts per species, and habitat type at each stop.

Repeatability: Standard methods (USFWS) used, replicable.

Timing: Ongoing surveys, no completion date.

Value to OIA Study: Location: Cumberland Route begins on US highway 189 south of I-80 and ends near Shurtleff and Clear Creeks; Diamondville-Carter route begins at Diamondville on US 189 and ends on Wyoming highway 412 approximately five miles northwest of Carter. The survey routes are near the eastern limit of the BRD study area. Counts are put into the WGFD Wildlife Observation System data base.

Subjective Evaluation of Information: The breeding bird surveys are standard means for obtaining trend data for the country but are subject to a variety of influences including weather, time of day, and observer capabilities. Raw data must be examined for annual variation and variation between stops for any given habitat type to determine species consistencies for habitat affiliations.

June, J.W. 1975. Annual upland game and small game and raptors, 1975 Completion Reports, District I and IV.

Oakley, C., D.C. Lockman, and J.W. June. 1976. Annual upland game and small game, 1976 Completion Reports, District IV.

Moody, D., and J.W. June. 1977. Annual upland game and small game, 1977 Completion Reports, District IV.

Roy, D.R., J.W. June, and D. Moody. 1978. Annual upland game and small game, 1978 Completion Reports, District IV.

June, J.W., D. Roy, and D. Moody. 1979. Annual upland game and small game 1979 Completion Reports, District IV.

Moody, D., J.W. June, and D. Roy. 1980. Annual upland game and small game, 1980 Completion Reports, District IV.

June, J.W., D. Moody, and D. Hays. 1981. Annual upland game and small game, 1981 Completion Reports, District IV.

Unpublished completion reports, Wyoming Game and Fish Department, Cheyenne, WY.. (ANALYZED DATA)
Location: WGFD, Cheyenne, WY.

Evaluation: The following information is contained in these annual reports: Sage grouse strutting ground trend counts for the given year and past five year comparisons; legal description of leks given in 1977 report only; sage grouse production trend counts (young per hen); harvest data trends (hunters, hunter days spent, birds per hunter, hunter days per harvest. Sage grouse data is compiled by county (Lincoln and Uinta) or by small game management area (eg. Uinta areas 5 and 6). Blue grouse hunter harvest data (see sage grouse) is compiled for Lincoln and Uinta Counties. Likewise, ruffed grouse, chukar partridge, Hungarian partridge harvest data are summarized by county. Cottontail rabbit roadside counts and density estimates are summarized for Uinta area 5 and 6. Densities (animals per mile and animals per square mile) are usually provided for the past six years. Snowshoe hare harvest data is summarized by county, no population trend data is given. Red Squirrel harvest data (see sage grouse) is also summarized by county. In the 1975 report, known raptor nest activity status and productivity data are summarized for District IV. Analysis Methods: Described above.

Value to OIA Study: Location: Information summarized by district, county or small game management unit encompasses the BRD study area. However, no routes driven nor locations of leks (except in the 1977 report) or harvests are given. Only gross trends are available for harvests and/or population indices.

Subjective Evaluation of Documents: These game bird and small game mammal information types are too general and summarized for large areas and can not be used as baseline data or for impact assessment.

Kesselheim, C. 1981 to 1982. Bird observations. Field notes.

Location: Evanston, WY. (RAW DATA)

Contact: Craig Kesselheim.

Evaluation: Design: Observations of bird species along the Bear River, Woodruff Narrows, and other locations within the BRD study area. Dates, counts, locations (general geographic areas) and miscellaneous comments on color phase, behavior, breeding activities, etc. are provided.

Value to OIA Study: These field notes supplement WGFD breeding bird surveys and other agency-related bird sighting reports.

Location: Many observations are within the BRD study area.

Subjective Evaluation of Information: These sightings provide valuable additions to other available information in documenting avian species occurrence in the study area.

Lockman, D.C. 1975. Big game survey, antelope, deer, elk, moose, District IV. Unpublished spot report, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: Design: Antelope counts on West Green River, Carter Lease, Church Buttes-Cedar Mountain areas. Gives sex/age ratios, harvest sex/age data by hunt area, comparisons of age compositions and percent bucks in harvest from 1971-1974 (from harvest questionnaire survey); Mule deer post hunt season sex/age composition counts and hunter success for the Lincoln and Uinta County areas. Statement of discontinuation of deer tagging studies in Crawford Mountains, at Sage Junction and in the Leroy area. Elk herd composition counts and elk harvest summarized for the Lincoln and Uinta areas. Moose harvest data by hunt area. Analysis methods: These data are summarized by hunt area or for hunt areas within Lincoln and Uinta Counties.

Value to OIA Study: Location: The areas covered in this report are quite large although the BRD study area is included within the various hunt areas.

Subjective Evaluation of Document: The population data presented is summarized for such large areas that use for baseline, pre-oil and gas development information is not possible.

Lockman, D. 1976. Mountain lion and wolverine sightings. Filed field data sheets, Wyoming Game and Fish Department, Green River District Office, Green River, WY. (RAW DATA)

Location: WGFD, Green River, WY.

Contact: Elaine Raper.

Evaluation: Observations: One sighting of a mountain lion on Dempsey Ridge east of Cokeville, one wolverine observed on Smiths Fork drainage. No specific locations given.

Value to OIA Study: Suggests that these species occur in areas adjacent to the BRD study area.

Subjective Evaluation of Document: Adds to anecdotal information for species occurrence although sightings are outside of study area.

Lockman, D. 1976 to 1979. Deer winter range reconnaissance survey. Filed data sheets, Wyoming Game and Fish Department, Green River District Office, Green River, WY. (RAW DATA)

Location: WGFD, Green River, WY.

Contact: Elaine Raper.

Evaluation: Design: Aerial survey of Cokeville area/ Rock Creek Ridge to Underwood Canyon and Crawford Mountains in Utah. Information includes snow/weather conditions, numbers of deer in a given group, tracks noted, mapped distributions (dots on 1:500,000 approximate scale map).

Value to OIA Study: Location: Mule deer occurrence within the BRD study area and north. Further study: Analysis of winter distributions compiled with other aerial distribution surveys could be done. Surveys are replicable for future efforts.

Subjective Evaluation of Information: Provides relative importance of areas surveyed to mule deer. Aerial surveys are assumed to represent attempts at total counts; no estimates of visibility biases or areas and deer not counted.

Lockman, D.C., and E. Heape. 1975, 1976. BQ pellet group transect Study. Filed data sheets, Wyoming Game and Fish Department, Green River District office, Green River, WY. (RAW DATA)

Location: WGFD, Green River, WY.

Contact: Elaine Raper.

Evaluation: Design: Mule deer and elk pellet group counts along Rock Creek drainage north of US highway 30 (winter range). Information includes number of pellet groups per plot, days use per acre, actual use in acres per AUM.

Exact location of transects is not given or was not found.

Value to OIA Study: Location is north of BRD study area although animals on BRD may move into the Rock Creek area. Further study: Variance estimations could be calculated from this data for future comparisons with similar data collected elsewhere. Generally, the information needs to be analyzed and examined in juxtaposition to winter range importance and with other winter ranges elsewhere.

Subjective Evaluation of Information: Potentially useful for future comparisons although pellet group data is of questionable value in estimating animal use of specific areas.

Lockman, D. C., and E. Heape. 1977. Rock Creek browse transects. and P. Mooney. 1977. Tump Ridge browse transects.

Filed data sheets, Wyoming Game and Fish Department, Green River District Office, Green River, WY. (RAW DATA)

Location: WGFD, Green River, WY.

Contact: Elaine Raper.

Evaluation: Design: Rock Creek: Form class, age class, percent leader use by plant and summarized by transect for serviceberry and mountain mahogeny. Tump Ridge: Line intercept distance, availability rating, vigor rating, hedging rating, density of willows, sagebrush, and snowberry. For both surveys photographs were taken at permanent

Lockman and Heape 1977, Lockman and Mooney 1977, cont.

photopoints, legal descriptions of transects given, and locations mapped on $\frac{1}{2}$ " to 1 mile BLM maps. Repeatability: The transects should be replicable.

Value to OIA Study: Location: North of BRD study area. Further study: These data could be used in future comparisons if comparable efforts are applied to similar habitat in BRD study area. Specific follow-up surveys would give indications of browse trends and big game and livestock use of areas near the transects. Data needs to be evaluated for variance and adequate sample size computation.

Subjective Evaluation of Information: Potentially useful for future comparisons although it is unlikely that sufficient sampling effort was applied. This needs to be determined.

Lockman, D.C. 1977. Elk response to seismograph activities. Unpublished letter to Phil Moffit, Kemmerer Ranger District, BTNF, Kemmerer District Office, Kemmerer, WY. (RAW DATA)

Location: US Forest Service, Kemmerer, WY.

Contact: Phil Moffit.

Evaluation: Anecdotal account of observations of elk responses to seismic charges and to helicopter activity in the Fontenelle Basin, Bridger-Teton National Forest. Charges 1.5 to 2 miles away evoke less overt behavioral response than approaching helicopters in response to which elk flee to cover.

Value to OIA Study: Substantiates other observations of elk behavioral response to helicopters.

Subjective Evaluation of Information: Points to concerns about intentional, or otherwise, big game harassment during exploration.

Lockman, D.C. 1981. Statement of justification for the redefinition of all or portions of the West Green River, Lincoln, Sublette, and Carter Lease deer herd units in western Wyoming. Unpublished report, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: Design: Deer tagged and marked from 1971 to 1980 and later harvested or observed were evaluated for movements from capture to harvest or relocation sites. From these data it appeared that there was substantial deer movement across established DAU boundaries. Lockman proposes changes in these boundaries and consolidation of portions of these herd units. Management applications of population simulation models are used to further justify these revisions. Analysis Methods: Summaries of marked and tagged deer relocations and a combined population simulation model for portions of these DAUs is said to more accurately depict the population levels from 1965 to 1978.

Value to OIA Study: Location: The Carter Lease is within

Lockman 1981, cont.

the BRD study area while West Green River, Lincoln and Sublette DAUs are north of US highway 30. In 1981 the northwest portion of the Carter Lease (Crawford Mountain area) was incorporated into the West Green River DAU. Use of historical data from these DAUs becomes difficult in trend analysis, especially when count data is presented and summarized for entire DAUs. Further study: The report provides a list of problems needing further study including interagency habitat objectives, lack of ecological information, lack of planning coordination between management agencies, the need for habitat improvement measures and mitigation efforts to compensate for lost or damaged habitat, and the need for public and manager awareness of wildlife-habitat interactions.

Subjective Evaluation of Document: Provides some compilation of deer movement data although this data represents only two points out of a year or more of movement. The information needs and necessary interagency and public cooperation recommendations are certainly valid.

Lockman, D.C. 1982. El Caballo subdivision proposal. Unpublished interdepartment communication, Wyoming Game and Fish Department Green River District Office, Green River, WY. (MISCELLANEOUS DOCUMENT)

Location: WGFD, Green River, WY.

Contact: Elaine Raper.

Evaluation: This memo states concern for wetland loss in general and on the upper Bear River flood plain (due to the proposed subdivision near Evanston) specifically. Canada goose production, nesting duck species, potential for whooping crane and long-billed curlew nesting habitat are cited as indications of importance and habitat diversity of this area.

Value to OIA Study: Only nesting data summaries are given for Canada geese (Woodruff Reservoir to Evanston). Further Study: Species concerns for lost wetlands with associated increased hunter demands. Needs for habitat acquisition and mitigation are outlined.

Subjective Evaluation of Document: Useful in pointing out wetland importance of BRD study area and suggesting information needs.

Lockman, D.C. 1976, 1977, 1978. Roy, D.R. 1979, 1980.

Antelope population investigations, Cokeville-Sage DAU.

Unpublished job completion reports for 1975 to 1979, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: The following information types are included in these job completion reports. Years for which the information is provided are in parenthesis. Antelope pre-

Lockman 1976, 1977, 1978. Roy 1979, 1980, cont.

season sex/age classification (1976,1978,1979,1980); post-hunt season classification(1976,1977); population trend count (1977, 1978); harvest questionnaire results yielding hunter percent success, days per animal taken, and hunter days spent (1976, 1977, 1978, 1979); hunter field check data (1976, 1977, 1978, 1979); harvest age structure (1978, 1979); road kills/illegal harvest (1976, 1977, 1979). Estimates for post-season populations and following year pre-season population projections are also provided in each report. The Cokeville-Sage DAU was merged with the Carter Lease DAU in 1981. This was done because the small herd in the vicinity of Leefe apparently interchanged with Carter Lease antelope. Analysis methods: Only summaries for the entire DAU are presented.

Value to OIA Study: Location: The Cokeville-Sage DAU borders the BRD study area on the northwest. Since data are summarized for the entire area specific densities and distribution for any particular area or for any one point in time are absent.

Subjective Evaluation of Documents: These reports provide large scale information representing one or two counts within a given year; there is nothing specific enough to use in evaluating impacts within a particular area of concern.

Lockman, D.C. 1976, 1977, 1978, Roy, D.R. 1979, 1980, 1981. Hays, D. 1982. Moose population investigations, Lincoln DAU. Unpublished job completion reports for 1975 to 1981, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location : WGFD, Cheyenne, WY.

Evaluation: The following information types are included in these job completion reports. Year for which the information is available are in parenthesis: Moose pre-hunt season sex/age composition (none); post-hunt sex/age composition (1976 to 1982); population herd trend counts (1976 to 1978, 1980, 1982); harvest survey questionnaire results yielding hunter percent success and days per animal taken (1976 to 1982); hunter field check data (1976, 1978, 1980, 1982); harvest age structure (1977,1978, 1979,1980, 1981, 1982); road kills, cripple loss and illegal harvest records (1976, 1977, 1978, 1982). Estimates for post-season population levels and following year pre-season population projections are also provided in each report. Composition counts and herd trend counts are broken down by geographic location in the following reports: 1976, 1977, 1978, 1980, 1982. Other information provided by year is listed: 1978: Locations of 8 browse transects were established along Hams Fork within the Bridger-Teton National forest. Locations and design of these transects are described; tagging and marking of moose in the northern portion of this DAU is described with information on 3 marked moose. Analysis Methods: With the exceptions noted above, most trend counts

Lockman 1976, 1977, 1978. Roy 1979, 1980, 1981. Hays 1982, cont.

and sex/age/composition counts are summarized by DAU or by hunt area. The same is true of harvest data.

Value to OIA Study: Location: The Lincoln moose DAU is north of the BRD study area (north of US 30). Movement of moose from this DAU to the Carter Lease DAU is unknown. Population data is summarized for large areas and is not appropriate for use in impact evaluation.

Subjective Evaluation of Documents: Because of the levels of area resolution, these documents do not contribute information useful for assessing impacts for oil and gas activities.

Lockman, D. 1976, Lockman, D., and A. Round 1977. Lockman, D. 1978. Roy, D.R. 1979, 1980, 1981. Antelope population investigations West Green River DAU.. Unpublished job completion reports for 1975 to 1980, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: The following information types are included in these job completion reports. Years for which the information is available are in parenthesis: Antelope pre-hunt season sex/age composition (1976 to 1981); post-season sex/age composition (none); population trend counts (1976, 1978, 1981); harvest survey questionnaire results yielding hunter percent success and days per animal taken (1976 to 1981); hunter field check data (1976, 1978, 1979, 1980, 1981); harvest age structure (1978 to 1981); illegal/road kill records (1976 to 1981). Estimates for post-season population levels and following year pre-season population projections are also provided in each report. Geographic locations are given for counts during 1977, 1978, and 1981 . A map (scale unknown) showing localized winter concentrations is provided in the 1978 report and one doe was examined for fetuses in 1978. Analysis methods: Sex/age compositions and population trend counts are either summarized by general geographic area (eg. east or west of US 189) or for the entire DAU.

Value to OIA Study: Location: The West Green River DAU is to the north and east of the BRD study area and extends east into Sweetwater County. With population data summarized for large areas or for the entire herd unit is unlikely that this information will be useful for baseline data in assessing oil and gas impacts. There are no indications that pronghorn migrate from this DAU to the Carter Lease DAU and BRD study area.

Subjective Evaluation of Document: This information is not resolved enough to be used for impact assessment.

Lockman, D.C. 1976, 1977, 1978. Roy, D.R. 1979, 1980, 1981. Mule deer population investigations, West Green River DAU. Unpublished job completion reports, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)
 Location: WGFD, Cheyenne, WY.

Evaluation: The following information types are included in these job completion reports. Years for which the information is available are in parenthesis: Mule deer pre-hunt season sex/age composition (none); post-season sex/age composition (1976 to 1981); population trend counts (none); harvest questionnaire results yielding hunter percent success and days per animal taken (1976 to 1981 broken down by hunt area); hunter field check data (1976, 1977, 1978, 1979, 1980); harvest age structure (1977, 1978, 1979, 1980); Illegal kill, road kill and cripple loss records (1976, 1977, 1978, 1979, 1980, 1981). Estimates for post-season population levels and following year pre-season population projections are also given in each report. Other information presented by year is listed: 1976: Results of the Fontenelle deer tagging project with sex, age, tag number and collar type listed for each deer captured. 1977: Recorded sightings of neck collared deer with some legal and some geographical locations recorded; listing of trapping and tagging sites from 1971 to 1977 with neck collar color per year and location; additional tagging information from 1976 tagging efforts. 1978: Reproductive information (fetus development) from 5 does; habitat monitoring program established on the Fontenelle-LaBarge Creek winter range with legal location of photopoints and principle plant species present; shrub utilization transects on Rock Creek Ridge, results of age study are presented for service berry, mountain mahogany and curled-leaf mahogany; recorded sightings of neck collared deer and hunter tag returns; additional tagging information from the Dry Hollow deer tagging study; map (scale unknown) of deer distribution documented during winter 1977-78.

1979: location of collared deer and tag returns from hunters. 1980: Graph of mule deer hunting pressure and harvest from 1966 to 1979; locations of collared deer and hunter tag returns. 1981: Graph of mule deer hunting pressure and harvest from 1966 to 1980.

Analysis methods: Sex/age composition counts and harvest information are summarized for the entire DAU, by hunt area, or by descriptive geographic location from one year to the next.

Value to OIA Study: Location: The West Green River DAU is to the north and east of the BRD study area and extends east into Sweetwater County. In 1981, this DAU and portions of the Carter Lease, Lincoln, and Sublette mule deer DAUs were combined to form the Wyoming Range mule deer DAU. This was done because deer move throughout the area and the new boundaries incorporate movements for the entire population. With population data summarized for large areas it would appear to be of little value in impact

Lockman 1976, 1977, 1978. Roy 1979, 1980, 1981, cont.

assessment. Further Study: The deer tagging and relocation data for all tagging studies needs to be combined and known movements summarized for evaluation.

Subjective Evaluation of Documents: The population data contained in these reports are not at high enough resolution to be useful for impact assessment. The tagging, reobservation and tag return information could be useful when it is finally compiled and analyzed for gross movement patterns.

Lockman, D.C. 1976, 1977, 1978. Roy, D.R. 1979, 1980, 1981. Elk population investigations, West Green River DAU. Unpublished job completion reports for 1975 to 1980, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)
Location: WGFD, Cheyenne, WY.

Evaluation: The following information types are included in these job completion reports. Years for which the information is available are in parenthesis: Elk pre-hunt season sex/age composition (1977 to 1980); post-season sex/age composition (1976 to 1981); population herd trend counts (1976 to 1978, 1980); harvest questionnaire results yielding percent success and days per animal taken (broken down by hunt area 1976 to 1981); hunter field check data (1978, 1979, 1980, 1981); harvest age structure (1976 to 1981); cripple loss, road kills and illegal harvest records (1977 to 1980); estimates for post-season population levels and following year pre-season population projections are also given in each report. Other information presented by year is listed: 1976: Elk winter distribution and movement map (scale unknown) for the western portion of the West Green River DAU; 1977: List of elk tag returns from tagging studies 1960 to 1971; Elk winter distribution and movement map for the western portion of the DAU. 1978: Marking codes for elk to be collared; records of tagged and marked elk during 1977-78 in the north-western portion of the DAU. 1979: locations of collared elk and additional elk tagged during 1978. 1980: Locations of observed collared elk and recoveries from hunters; graph of number of hunters and elk harvest from 1971 to 1979.

Analysis methods: Sex/age composition counts and harvest information are summarized for the entire DAU, by hunt area, or by descriptive geographic location. These may vary from one year to the next, especially with composition and herd trend counts.

Value to OIA Study: Location: The West Green River Elk DAU is north of the BRD study area. There may be movement of elk from this DAU into the Carter Lease DAU during winter. Further study: the Elk tagging and relocation data for all tagging studies needs to be combined and known movements summarized.

Subjective Evaluation of Documents: The population data contained in these reports are not at high enough resolution to be used for impact assessment. Where winter distribution data is mapped, considerable variation is evident between years and appears to be dependent on winter severity. This type of annual variation information is necessary before variation due to impacts can be analyzed.

Loeper, D. 1967. Bear River Divide browse transects and pellet group study.

1968. Browse study, Underwood Canyon and Leige Creek. Filed data sheets, Wyoming Game and Fish Department, Green River District Office, Green River, WY. (RAW DATA)

Location: WGFD, Green River, WY.

Contact: Elaine Raper.

Evaluation: Design: Wildlife and livestock use of browse species. Provides form class, age class, percent leader use.

Only general geographic locations of transects are given.

These may be assumed to be the same browse and pellet group transects reported by Julian 1970, 1972 and 1973.

Value to OIA Study: Very little value because of general locations given. Further study: Analysis of this data would have to be done so that adequate sample size for future investigations could be determined. However, because the information is broken down into class categories its replicability might be limited.

Subjective Evaluation of Information: Because of limited replicability, this data and other information in subsequent studies has little utility.

Martin, S.J., and M.H. Schroeder. 1979, 1980. Black-footed ferret surveys on seven coal occurrence areas in southwestern and southcentral Wyoming. Unpublished final reports, Wyoming State Office, Bureau of Land Management, Cheyenne, WY. (ANALYZED DATA)

Location: USFWS, Denver Wildlife Research Center, Denver, CO.

Contact: Max Schroeder.

Evaluation: Design: 1978 and 1979 surveys of white-tailed prairie dog towns in the vicinity of the South Haystack proposed mine site (see Berry 1982) were conducted to document black-footed ferret sign or occurrence. Day time searches documented prairie dog behavior, prairie dog town boundaries and hole counts, ferret skeletal remains and possible scat, and occurrence of other mammals, birds and herpetofauna observed during the course of the surveys. Analysis methods: Prairie dog towns searched were mapped and acreage and hole density determined. Ferret skulls found in 1978 and 1979 were sent to US National Fish and Wildlife Laboratory, Fort Collins CO. and US National Museum in Washington, D.C. for positive identification. One skull was found in 1978 and two located in 1979. Several trenches were also found. The results of night spotlighting for ferrets were negative.

Value to OIA Study: Location: The South Haystack area is within the BRD study area. Conclusions: Ferrets occur or have occurred within the surveyed areas. Other species observed during these surveys complement and supplement others species' observations reports and further document which wildlife species are in the BRD study area. Further study: These surveys should probably be continued

Martin and Schroeder 1979, 1980, cont.

and expanded to include other prairie dog colonies not documented or that have not been surveyed.

Subjective Evaluation of Documents: These represent standard USFWS black-footed ferret surveys and provide the best information available on this species' occurrence in the BRD study area.

Martin, S.J., and M.H. Schroeder. 1981. Black-footed ferret survey on historic and recent sighting areas in Wyoming. Unpublished final report, US Fish and Wildlife Service, Denver Wildlife Research Center, Fort Collins, CO. (ANALYZED DATA)
Location: USFWS, Denver Wildlife Research Center, Denver, CO.
Contact: Max Schroeder.

Evaluation: Design: Two areas adjacent to the BRD study area were searched for ferret sign and occurrence. One was in Rich County, UT one mile from the Wyoming boarder and west of Woodruff Reservoir, the other was 5 miles north of Kemmerer. Analysis: Only the number of holes examined and a map of the Rich County towns examined are presented. Value to OIA Study: Conclusion: No ferret sign was discovered at either of the two locations near the BRD Study area. The survey does add to the number of prairie dog towns inventoried.

Subjective Evaluation of Document: With only the two areas listed as surveyed, this study has limited value except to point out that repeated ferret sightings in the region may be indicative of an extant population within or near the BRD study area.

McCuistion, R. 1979 to 1980. Browse transects.
1979 to 1980. Northwest Cumberland Allotment pellet group survey.

Filed data sheets, USDI, Bureau of Land Management, Kemmerer Resource Area office, Kemmerer, WY. (RAW DATA)

Location: BLM, Kemmerer or WGFD, Green River.

Evaluation: Design: Pellet group transects for deer, elk and sage grouse were conducted in the Spring Creek-Bridger Creek (T20N, R120W) area. Pellet counts per species and counts per plot for each of 7 plots are provided on raw data forms. Browse transects on Rock Creek Ridge (T22N to T24N, R118W to R119W) provided shrub form class, age class, percent leader use on 7 transects. Timing: Unknown if these surveys are to continue or will be expanded.

Value to OIA Study: Location: Pellet group study is within BRD study area; Browse study is north of US highway 30.

Both studies are on mule deer and elk winter range. Further study: These data might be useful for comparisons of future survey results although class data may be subject to observer bias.

Subjective Evaluation of information: Some potential for future use.

McCuistion, R. 1981 to 1982. Winter aerial counts of big game. Unpublished data and overlays, USDI, Bureau of Land Management, Kemmerer Resource Area Office, Kemmerer, WY. (RAW DATA-MAPPING)
Location: BLM, Kemmerer, WY.
Contact: Dick McCuistion.

Evaluation: Design: Aerial surveys were conducted in February and March from Bridger-Teton National Forest to I-80 encompassing the area between Oyster Ridge and the Utah boundary to the west. Counts of mule deer, elk, moose, pronghorn, feral horses were placed on $\frac{1}{2}$ " to 1 mile overlays for each year surveyed. Timing: Expected to continue for winter 1983.

Value to OIA Study: Counts of deer coincide with WGFD winter range boundaries. Most deer in BRD study area were observed in the northwest portion of the Cumberland Allotment, very few located in southern portion near I-80.

Subjective Evaluation of Information: Best information available on big game winter distributions. However, there is variation between years and only long term surveys compiled for winters of varying severity will yield information about the effects of oil and gas developments present on designated winter range. Also, these counts represent efforts spread over several days and there is no way to determine whether animals were counted on repeated occasions or if animals were missed due to movements in and out of areas already counted.

McDonal, W.N., and M.H. Schroeder. 1981. Black-footed ferret surveys conducted along Mapco, Inc. pipeline routes in southwestern Wyoming, 1980. Unpublished final report, US Fish and Wildlife Service, Denver Wildlife Research Center, Denver, CO. (ANALYZED DATA)

Location: USFWS, Denver Wildlife Research Center, Denver, CO.
Contact: Max Schroeder.

Evaluation: Design: White-tailed prairie dog towns along the proposed Mapco pipeline right-of-way were initially mapped from the air and later surveyed on the ground for ferret sign or occurrence. 15 towns on the proposed north leg of the pipeline (T18N to T21N, R112W to R114 W) were included in the survey. Analysis methods: Summaries of numbers of towns, town acreage, and burrows/acre as well as other survey-related summaries are presented. Also, species lists of mammals, birds, and herpetofauna observed during the entire survey are presented.

Value to OIA Study: Location: North leg of the Mapco pipeline right-of-way is east and north of the BRD Study area.

Conclusions: No ferrets or conclusive ferret sign were observed. Prairie dog town mapping efforts add to the number of towns inventoried and surveyed in the region.

Subjective Evaluation of Document: The study has little value since it was east of the BRD study area and gross summaries of prairie dog town parameters are presented.

Miller, D.D. 1977. Comprehensive survey of the Bear River drainage. Project 4077-01-6602. Unpublished completion report, Wyoming Game and Fish Department, Fish Division, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: Design: Data on land ownership, average flows, water temperature, pH, conductance, riparian and aquatic vegetation descriptions, game and non-game fish species known to be present, and stocking histories are given for streams within the drainage. Timing: 1966 to 1977, continuation or follow-up studies are unknown. Analysis methods: stream by stream summaries of estimated channel width, estimated flow, total alkalinity, hardness, pH, oxygen, water temperature, conductivity, stream velocity, USGS streamflow at gauging stations, and electrofishing results (distance sampled, estimated numbers of trout per mile, estimated pounds per acre, numbers and mean length of game species including Bonneville cutthroat trout, and presence of non-game species) are presented. Similar data are given for lakes, ponds, and reservoirs in the drainage.

Value to OIA Study: Location: BRD study area surveyed includes Bear River above and below, Woodruff Reservoir, Twin Creek, Rock Creek, Yellow Creek, Sulfur Creek, Mill Creek, Sulfur Ck. Reservoir, Myers Reservoir, U.P. Ice Ponds Crompton Reservoir, Woodruff Reservoir, State Hospital Pond, City Dairy Pond, and other streams and standing waters north of the BRD study area. Repeatability: The survey is repeatable for future comparisons with pre-oil and gas development data. Further study: Information in this study needs to be combined with other stream and standing waters surveys so that streams and standing waters that are not inventoried can be discerned.

Subjective Evaluation of Document: Useful information on a stream by stream and reservoir by reservoir basis. Much of this information is included in WGFD stream-pond-reservoir data base and contained in Fish Division files in Cheyenne.

Monarch, J. 1977. Haystack coal mine site, wildlife study.

Filed data sheets, Peter Kiewit and Sons Mining and Engineering Company, Sheridan, WY. (RAW DATA)

Location: Copies on file at WGFD, Green River, WY.

Contact: Elaine Raper.

Evaluation: Design: Raw data on mule deer winter counts, locations, and general behavior on the Cumberland Coal South Haystack mine site.

Value to OIA Study: Little value, one season's observations within a limited area. Further study: Data could be plotted for distribution and compared to future distributions for annual variation estimates.

Subjective Evaluation of Information: Not directly applicable to main area of oil and gas development although within BRD study area. Inappropriate for use as baseline data because of limited geographic area covered.

Mooney, P. 1981. Seismic helicopter disturbance of elk.
 Filed letter, USFS, Kemmerer Ranger District, Kemmerer, WY.
 (RAW DATA)

Location: USFS, Kemmerer, WY.

Contact: Phil Mooney.

Evaluation: Anecdotal account of elk and approaching helicopters on Little Hornet Creek in BTNF during May 1981. Two helicopters three miles away sent elk into dense timber. Recorded violation of seismic helicopter avoidance of elk calving areas stipulations.

Value to OIA Study: Little value except to re-iterate elk sensitivity to helicopter disturbance and the fact that even with stipulations to exploration permits violations do occur.

Subjective Evaluation of Information: Anecdotal accounts such as this point out need for research on effects of oil and gas activities on elk and other big game species before and during the development process.

Morrison-Knudsen Company. 1981. Appendix D9, Wildlife for the FMC Corporation Skull Point Mine, Kemmerer, Wyoming. Unpublished appendix to mine plan, Morrison-Knudsen, Co., Inc. Boise, ID.
 (ANALYZED DATA)

Location: Land Quality Division, Department of Environmental Quality, Cheyenne, WY.

Evaluation: Design: Small mammal live trapping provides relative abundance and habitat affinities, lagomorph sightings along bird transects and casual observations, prairie dog towns surveyed from air with ground truthing, predators sighted opportunistically, raptors were surveyed during winter from the air and aerial and ground surveys were conducted for nesting raptors, sage grouse lek surveys were conducted from the air and on ground for counts, passerine transects for breeding birds (used King estimator for species densities) waterfowl identified by ground searches, searches in prairie dog towns for black-footed ferret occurrence and sign, bald eagle observations are noted. Timing: Study is completed.

Value to OIA Study: Location: Study area is within BRD study area (T20N, R117W). Methods and analyses are standard and replicable. Species occurrence and habitat affinities might serve as comparisons for studies conducted elsewhere in BRD study area.

Subjective Evaluation of Document: Some good quantitative information on species-habitat affinities. Study area is limited geographically.

MAPPING: Type of Map: Vegetation. Area covered: Approximately 3 sq. mi. within T20N, R117W. Scale: 1" = 400' (1:4800).

Evaluation: Vegetation types: Big sage/grassland, sparse shrub, Amalanchier/sagebrush, big sagebrush drainage, shallow sandy, wetland shrub, and willows. Map locations of vegetation transects and exclosures on proposed mine area and off on control areas. Ground truthed.

Subjective Evaluation of Map: Limited area covered by map.

Morrison-Knudsen 1981, cont.

MAPPING: Type of Map: Passerine transects and Raptor nests.

Area covered: Same as above. Scale: Same as Above.

Evaluation: Information Mapped: Passerine bird transect locations, locations of incidental sightings (eg. where female widgeon was flushed), nest sites of 3 raptor species.

Subjective Evaluation of Map: see above.

MAPPING: Type of Map: Pronghorn distribution. Area covered: Same as above. Scale: Same as above.

Evaluation: Pronghorn distribution during four formal observation periods spring, summer, fall, and winter 1978-1979. Unknown whether individual pronghorn marked on map are the same individuals observed each period.

Subjective Evaluation of Map: see above.

MAPPING: Type of map: Mule deer distribution. Area covered: Same as above. Scale: Same as above.

Evaluation: Mule deer distribution during four formal observation periods. See pronghorn, above.

Subjective Evaluation of Map: see above.

MAPPING: Type of Map: Sage grouse distribution. Area covered: Same as above. Scale: Same as above.

Evaluation: Sage grouse distribution during four formal observation periods. See pronghorn, above.

Subjective Evaluation of Map: see above.

MAPPING: Type of Map: Raptor distribution. Area covered: Same as above. Scale: same as above.

Evaluation: Raptor distributions from aerial survey conducted during spring 1978 (ground verification period) and summer fall, and winter (aerial survey only) 1978-1979.

Subjective Evaluation of Map: see above.

MAPPING: Type of Map: General distribution of wildlife species. Area covered: Same as above. Scale: Same as above.

Evaluation: Summaries of wildlife sightings during four formal observation periods. See pronghorn, above. Species observed include badger, pygmy rabbit, desert cottontail, striped skunk, red fox, coyote, muskrat, marmot.

Subjective Evaluation of Map; see above.

Morrison-Knudsen Company. 1981. Appendix D8, vegetation inventory for the FMC Corporation Skull Point Mine, Kemmerer, Wyoming. Unpublished appendix to mine plan. Morrison-Knudsen Co., Inc. Boise, ID. (ANALYZED DATA)

Location: Land Quality Division, Department of Environmental Quality, Cheyenne, WY.

Evaluation: Design: Six vegetation types: Amelanchier/big sagebrush, big sagebrush/grassland, big sagebrush/drainage, sparse shrub, shallow sandy, wetland/shrub. Fifty meter transects conducted within each vegetation type to measure cover and shrub height, Exclosures in affected and control areas to determine standing crop and biomass estimates. Also provides vegetation species list, acreage of cover types, and topography relationships. Analysis methods: Calculated sample size adequacy, used sound sampling procedures.

Morrison-Knudsen 1981, cont.

Value to OIA Study: Location: Study area is within BRD study area (T20N, R117W). Sampling procedure and study design are repeatable. Comparisons of similar vegetation types surveyed in the future could be made.

Subjective Evaluation of Document: Good data and analyses, the study site is geographically limited and not all vegetation types occurring in the BRD study area were examined.

Oakleaf, R. 1979. Raptor habitat study on state and private lands, bald eagle progress report. Unpublished project report, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)
Location: WGFD, Cheyenne, WY.

Evaluation: Design: Compilation of Wyoming bald eagle nesting surveys and wintering surveys. Provides observed numbers of bald eagles at Rock Creek and Woodruff Narrows winter roosts in February 1979.

Value to OIA Study: Conclusions and Recommendations:
For nesting bald eagles keep nest locations confidential; no habitat alterations within a 100 meter radius of a nest; don't disturb nest and roosting trees; for roosting bald eagles minimize human activity; maintain area vegetation for wind breaks; maintain large snags; manage the ecosystem for prey species diversity; remove road killed big game well away from roadside to reduce possible vehicle collisions.

Subjective Evaluation of Document: Use of the Woodruff Narrows and Rock Creek winter roosts is documented. Recommendations are perhaps the best information in the report for use in mitigation efforts.

Oakleaf, R. 1981. Nongame bird inventories. Annual completion report. Unpublished report, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)
Location: WGFD, Cheyenne.

Evaluation: Design: Bird communities in aspen stands were evaluated on three 12 hectare plots using visual and audible cues. Census plots were mapped according to habitat structure. Bird species lists and density estimates are given for each of four study sites.

Value to OIA Study: Location: All study plots were north of the BRD study area in the upper Green River drainage. Conclusion: Aspen plant communities have a unique assembly of non-game bird species. Further study: This study should be expanded to include aspen communities on the BRD study area. The results of bird community surveys elsewhere could serve as comparisons for surveys on the BRD.

Subjective Evaluation of Document: Study areas are well outside of the BRD study area but the information and survey design might be applied to future efforts on the BRD.

Oakleaf, R., H. Downing, B. Raynes, M. Raynes, O.K. Scott. 1982. Wyoming avian atlas. Wyoming Game and Fish Department and the Bighorn Audubon Society. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: Design: Documented occurrence of bird species by degree blocks (latilongs) within Wyoming. BRD study area falls within degree Block 22 (Fort Bridger). For each species occurring within degree block 22, the occurrence is noted as breeding (actual or circumstantial), historically or recently observed, records needing further verification, whether or not a specimen or photographic record is available, habitats used by the species, habitation status, abundance status, and life form category are noted. Timing: Updated as new information is available.

Value to OIA Study: Although this is broad scale information, species listed for degree block 22 indicates what might be expected in the BRD study area.

Subjective Evaluation of Document: Too general for baseline use.

Orpet, J. E. 1976. Boulder Ridge mahogeny and Rock Creek exclosure study. Filed data sheets, Wyoming Game and Fish Department, Green River District Office, Green River, WY. (RAW DATA)

Location: WGFD, Green River, WY.

Contact: Elaine Raper.

Evaluation: Design: Three sets of exclosures for big game and livestock within T22N, R119W. Raw data includes average percent cover by plant species and percent frequency by species. No indications of follow-up studies are provided.

Value to OIA Study: Location: These areas are north of the BRD study area but include important winter range to mule deer and elk. Since no methods and limited locations of the exclosures are provided it might be difficult to replicate the study. It is unknown whether the exclosures are still intact.

Subjective Evaluation of Information: Raw data can be analyzed for within and between exclosure variation but this would have little use if the study can not be replicated. There are several browse studies in the same general area and these all need to be compiled and evaluated to determine whether this information has any significant meaning before follow-up studies are initiated.

Phillips, R.L. 1982. Raptor inventory of the Green River-Hams Fork coal region. Unpublished report, U.S. Fish and Wildlife Service, Denver Wildlife Research Center, Sheridan, WY. (ANALYZED DATA)

Location: USFWS, Sheridan, WY.

Contact: Bob Phillips.

Evaluation: Design: Aerial searches for raptor nest sites in northwest Colorado and southern Wyoming for golden eagles, ferruginous hawks and prairie falcons. Nest

Phillips 1982, cont.

sites were mapped and location date, species, nest number substrate type, nest activity status, UTM X and Y coordinates, state, county, legal description, coal area and map quad name were recorded. Analysis methods: Summary results of nests located for the three species by BLM district in Colorado and Wyoming are given and comparisons of golden eagle and ferruginous hawk nesting substrates in the two states are presented.

Value to OIA Study: Nests for these three species within the Rock Springs BLM district are on file with USFWS in Sheridan. Further study: These nest site data need to be combined with other reports of raptor nests so that the BRD study area can be evaluated for raptor species use and to identify areas that have not been searched.

Subjective Evaluation of Document: No information on specific areas is available. The raw data on file in Sheridan would have to be examined to see which areas in and near the BRD study area have been searched.

Remmick, R. 1981. A comprehensive survey of the Green River westside tributaries. Project 4079-01-6202. Unpublished completion report, Wyoming Game and Fish Department, Fish Division, Cheyenne, WY (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: Design: Data on land ownership, average stream flows, channel width, alkalinity, hardness, pH, conductance, descriptions of riparian and aquatic vegetation, game and non-game fish species from electrofishing surveys, and stocking histories are given for many streams and standing waters within the westside Green River tributaries (Blacks Fork, Henrys Fork, Slate Creek, Fontenelle Creek, Muddy Creek, LaBarge Creek drainages and others north of the BRD study area). Timing: 1962 to 1979 surveys, no further studies or continuations are suggested. Analysis methods: Quantitative evaluations of stream and standing waters physical characteristics (see above) and electrofishing results (distance sampled, trout per mile, trout pounds per acre, numbers and mean length of game fish sampled, and listings of non-game fish sampled).

Value to OIA Study: Location: BRD study area surveyed includes Hams Fork drainage north and east of Kemmerer, Little Muddy Creek drainage east of US 189, and the Muddy Creek drainage south of I-80 to the Utah boarder. Repeatability: All sampling procedures are standard and sampling locations are documented for future replicable studies. Further study: Information in this study needs to be compiled with other stream and standing waters surveys so that water resources that have not been inventoried can be discerned.

Subjective Evaluation of Document: Useful information on a stream by stream and individual standing waters basis. Much of this same information is included in WGFD stream-pond-reservoir data base and contained in Fish Division files in Cheyenne.

Richards, C, and P.B. Holden. Volume I, Phase III - Final Report. Fisheries distribution and species composition inventory, Rock Springs/Salt Wells Resource Area, Wyoming. Unpublished report to Bureau of Land Management, Wyoming State Office, Cheyenne, WY. (ANALYZED DATA)
Location: BLM, Cheyenne, WY.

Evaluation: Design: Streams in the Salt Wells BLM Resource area were sampled for fish species occurrence. Additional species known to occur from available documents were listed. Timing: The study was completed in 1980. No further studies are anticipated. Analysis methods: Results of fish sampling at each sample station are provided with collection dates, collector, legal description and fish species reported for this study and other documented studies. Stream by stream accounts of fish species collected and age composition of collections as well as species size frequency distributions are given.

Value to OIA Study: Location: the western portion of this study encompasses stretches of the Blacks Fork, Cottonwood Creek Sage Creek and Henrys Fork drainages lying on the eastern portion of the BRD study area. Baseline data: These collections provide documentation of species occurrence and population attributes useful in future comparative studies.

Subjective Evaluation of Document: The area covered in this study barely touches on the BRD study area. The information, however, could be useful in combination with similar studies conducted on Green River drainages to define species range of occurrence in the study area.

Rothwell, R., G. Skutches, J.R. Straw, C. Sax. H. Harju. No Date.

A partial bibliography of the mammals of Wyoming and adjacent states with special reference to density and habitat affinity. Unpublished report, Bureau of Land Management and Wyoming Game and Fish Department. (ANALYZED DATA)

Location: WGFD, Cheyenne or BLM, Cheyenne, WY.

Evaluation: Design: A bibliography of published and unpublished accounts of mammals by species and in general. Covers studies in Wyoming and Rocky Mountain region. Also, a species by species list of occurrence in general habitat types. Results of specific studies dealing with mammal-habitat associations are given as a type of annotation. Analysis methods: Density estimates by species for BLM habitat types are tabulated with density values gleaned from the literature. Population growth predictions for selected species are also tabulated.

Value to OIA Study: No accounts of studies done in the BRD area are given. Density estimates and the bibliography itself should be useful in future evaluations.

Subjective Evaluation of Document: Not useable for evaluations of current and future impacts. This information can not be used as a substitute for site-specific baseline data.

Saul, R.H. 1971. Influence of man-made nesting structures on Canada geese. Unpublished M.S. Thesis, University of Wyoming, Laramie, WY. (ANALYZED DATA)

Location: University of Wyoming, Laramie, Science Library.

Evaluation: Design: 3 Canada goose nesting areas, two south and one north of Cokeville. Maps of nesting structures, successful and unsuccessful nests 1969 and 1970, and vegetation and water distribution are provided for each of the nesting areas. Area #1 contained established nesting structures, area #2 had no artificial structures, and area #3 had new structures constructed in 1967. Analysis Methods: Time-line nesting phenology for Bear River Canada geese, specific locations of geese and nests counted in 1969 and 1970, qualitative evaluations of nesting success for ground nesting and various structure nesting geese, and individual structure utilization data are presented. Timing: Part of a six year study.

Value to OIA Study: Location: In vicinity of BRD study area although further north than primary area of concern.

Conclusions: Artificial nesting structures produce over half the young leaving the Bear River area near Cokeville.

Structures offer freedom from nest flooding by irrigation.

After structures were placed on area #3 in 1967, number of nests increased dramatically by 1969.

Subjective Evaluation of Document: Supplements other nesting structure studies done in area. The importance of nesting structures to geese nesting in agricultural areas is emphasized and may be useful for future enhancement projects.

Saul, R.H. 1979. Annual game bird survey, waterfowl.

Serdiuk, L. 1980. Annual game bird survey, waterfowl.

Serdiuk, L., and R. Saul. 1981. Annual game bird survey, waterfowl.

Unpublished reports, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: Design: These reports give the following information: Canada goose breeding ground surveys on the Bear River area and provide comparisons with the previous five years; numbers of geese banded along the Bear River, 1978 to 1980, and numbers banded at Woodruff Reservoir in 1978; band recoveries from geese tagged in the Bear River drainage indicating dispersal throughout the western United States; numbers of hunters, hunter days, and harvest summarized for the Western Reference Area (includes Teton, Lincoln, Sublette, Uinta, and Sweetwater counties). Analysis methods: Breeding ground surveys and harvest data tabulated and summarized. Trends for previous five year periods are tabulated.

Value to OIA Study: Location: Breeding ground counts and tagging projects are within BRD study area. No conclusions are presented but these data confirm importance of the Bear River to nesting geese and the Rock Mountain Canada goose population.

Subjective Evaluation of Documents: Count data are summarized for undefined areas (Bear River breeding grounds) and are useful for use trends but not for specific area impact assessments.

Stoecker 1981, continued.

Value to OIA Study: Location: Study area is within the BRD study area. Methods and analyses, where presented, are standard and replicable. Species occurrence and habitat affinities might serve as comparisons for studies conducted elsewhere in BRD study area.

Subjective Evaluation of Document: Some quantitative information on species-habitat associations. These data could be compiled with other similar data to examine variability between similar habitats. The study area is limited geographically.

MAPPING: Type of Map: Wildlife surveys. Area Covered: Portions of T20N to T21N and R117W. Scale: 1" = 400' (1:4800).

Evaluation: Information Mapped: Location of breeding bird transects, wildlife observation routes, big game and avifauna observation sites, mine pit boundary, habitat type boundaries, small mammal transects, active raptor nests, big game pellet group transects.

Subjective Evaluation of Map: limited area covered by map. Information mapped provides graphical locations of wildlife survey efforts but no useable information.

Strickland, D. 1978. Current status of the bobcat in Wyoming.

_____. 1980. Bobcat report.

_____. 1981. Population analysis of bobcats in Wyoming 1980-81.

Unpublished reports, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: Design: Bobcat information summarized for the state of Wyoming includes: pelt sales, density by potential vegetation type (after Kuchler) rated as high, medium and low, estimated bobcat numbers. 1980 and 1981 reports provide corpora lutea and placental scars for bobcat ovaries and uteri collected winter 1980-1981, statewide ONEPOP model, and density estimates from USFWS scent post surveys. Analysis methods: State wide summary estimates in tabular form. Timing: Assumed to continue as more information is available.

Value to OIA Study: Location: Statewide, no smaller units of analysis. Conclusions: Density estimates by potential vegetation type could be extrapolated to vegetation within the BRD study area. This is not useful as baseline data but only for expected occurrence.

Subjective Evaluation of Documents: There are no specific data provided for the study area. The information reported can not be used as either baseline data or for impact assessment.

Thompson, W.W. 1969. Cover establishment on strip-mined area using two rhizomatous grass species. Unpublished M.S. Thesis, University of Wyoming, Laramie, WY. (ANALYZED DATA)
 Location: University of Wyoming, Laramie, Science Library.
 Evaluation: Design: Research done at the Kemmerer coal mine to assess the effects of different treatments in mine overburden revegetation efforts. Sprigging and sodding techniques were used to plant mature grass rather than using seeding and seedling stages. Plantings at different times of year, on different ages of overburden piles, on different slopes and aspects, with and without snowfence treatment. Analysis Methods: Quantitative comparisons of Agropyron smithii and Distichlis spicata survival with the various treatments, above. Timing: Study was completed in 1968.

Value to OIA Study; Location: Kemmerer Coal Mine is within the BRD study area. Conclusions: Sodding results were better better than sprigging although precipitation regime in area makes sodding economically prohibitive. Other conclusions based on various treatments are of interest. The design of this study could be replicated with revegetation efforts on access roads and drill pads for comparative purposes.

Subjective Evaluation of Document: Potentially useful information for applying to revegetation projects in the BRD study area although soils and site differences will make comparisons to this study difficult.

USDI, Bureau of Land Management. 1956. Aerial photographs.
 Source: USDA, Commodity Stabilizing Service.
 Location: BLM, State Office, Cheyenne, WY.
 Contact: Bruce Keating.
 Evaluation: Area Covered: Lincoln County, Wyoming. Scale: 1:20,000. Type: Black and white from composite photographs.

USDI, Bureau of Land Management. 1960. Aerial photographs.
 Source: USDA, Commodity Stabilizing Service.
 Location: BLM, State Office, Cheyenne, WY.
 Contact: Bruce Keating.
 Evaluation: Area Covered: Uinta County, Wyoming. Scale: 1:20,000. Type: Black and white from composite photographs.

USDI, Bureau of Land Management. 1964. Aerial photographs.
 Source: USDA, Agriculture Stabilization and Conservation Service.
 Location: BLM, State Office, Cheyenne, WY.
 Contact: Bruce Keating.
 Evaluation: Area Covered: Lincoln County, western portion. Scale: 1:20,000. Type: Black and white from composite photographs.

USDI, Bureau of Land Management. 1971 and 1973. Range trend plot data, Cumberland Allotment. Filed data, Bureau of Land Management, Kemmerer Resource Area Office, Kemmerer, WY. (RAW DATA)

Location: BLM, Kemmerer, WY.

Contact: Pat Netherly.

Evaluation: Design: Six 3'x3' plots on Cumberland Flats, Bear River Divide, northern Bridger Basin, and Alkali Creek. Plots are permanent with photo points. Raw data includes number of plants (grasses, forbs, and shrubs) and size of plants. Photos were taken in 1971 and 1973 for trend analysis. Timing: Apparently no further study occurred after 1973.

Value to OIA Study: Location: Plots are within the BRD study area. Baseline Data: The collected data and trend photos could be used as baseline information except for the small sample size. Further Study:

A comprehensive vegetational trend study needs to be conducted in all major habitat types in the study area.

Subjective Evaluation of Information: Because of the limited sample size this information is not very useful. It would be interesting to do a follow-up analysis on these plots to compare trends with 1973 data.

USDI, Bureau of Land Management. 1974. Aerial photographs.

Source: Bureau of Land Management.

Location: BLM, State Office, Cheyenne, WY.

Contact: Bruce Keating.

Evaluation: Area Covered: Uinta and Lincoln Counties, T12N to T23N, R111W to R121W. Scale: 1:31,680. Type: Color IR.

USDI, Bureau of Land Management. 1976 and 1977. Aerial photographs.

Source: Bureau of Land Management.

Location: BLM, State Office, Cheyenne, WY.

Contact: Bruce Keating.

Evaluation: Area Covered: Uinta and Lincoln Counties, T12N to T23N, R111W to R121W. Scale: 1:24,000 enlargements from scale 1:80,000 originals. Type: Black and white, quad centered orthoquads.

USDI, Bureau of Land Management. 1976. Overlay: Wildlife habitat.

Bureau of Land Management, Kemmerer Resource Area Office, Kemmerer, WY. (MAPPING)

Location: BLM, Kemmerer, WY.

Evaluation: Area Covered: Pioneer Trails Planning Unit.

Scale: $\frac{1}{2}$ " to 1 mile. Resolution: Less than one square mile.

Ground Truthed: Unknown. Information Mapped: Winter, yearlong, summer ranges for game birds including ducks, geese, grouse, and partridges.

Subjective Evaluation of Map: Useful for identifying general areas of concern. Most information is from WGFD. Delineation of seasonally used areas is inferred from several years' observations, but no quantitative data are known for map.

USDI, Bureau of Land Management. 1976. Overlay: Forestry.
 Bureau of Land Management, Kemmerer Resource Area Office,
 Kemmerer, WY. (MAPPING)
 Location: BLM, Kemmerer, WY.
 Evaluation: Area Covered: Pioneer Trails Planning Unit.
 Scale: $\frac{1}{2}$ " to 1 mile. Resolution: Less than one square mile.
 Ground Truthed: Unknown. Information Mapped: Boundaries
 of timber, Christmas tree, juniper, aspen stand, ownership
 and USBR revocation areas.
 Subjective Evaluation of Map: Useful for identification of
 general areas and general forest types. No quantitative
 data have been found to accompany these types.

USDI, Bureau of Land Management. 1977. East Front aquatic habitat
 management plan. W-041-WHA-A1. Bureau of Land Management,
 Rock Springs District Office, Rock Springs, WY. (ANALYZED DATA)
 Location: BLM, Rock Springs, WY.
 Evaluation: Design: Management objectives, planned actions
 for priority areas, and proposed interagency coordination
 of timber, livestock, recreation, watershed, wild horse,
 minerals and fire management in the east front aquatic
 habitat area relative to protection and improvement of
 Colorado cutthroat habitat. Analysis Methods: Appendices
 provide summarized stream habitat data for the eastern front
 area and for individual streams within this area.
 Value to OIA Study: Location: East Front area is northeast of
 BRD study area, T26N to T34N, R110W to R114W. Conclusions:
 Proposed actions to insure survival of Colorado cutthroat
 trout include land classification changes, aspen re-growth
 efforts, and stream rehabilitation projects. These management
 procedures, if successful, could be applied to other areas
 in need of riparian and aquatic rehabilitation, whether or
 not cutthroat trout potential habitat exists. Further
 Study: This project should be continued.
 Subjective Evaluation of Document: Since the target area on
 the East Front is well outside the BRD study area, this
 report has no direct applicability for use as baseline
 information or management directions. However, relevant
 procedures and priority discussions are applicable to
 the BRD area and could be employed in future mitigation
 projects.

USDI, Bureau of Land Management. 1978. BLM compiled active raptor
 nests. Filed data sheets, Bureau of Land Management, Rock
 Springs District Office, Rock Springs, WY. (RAW DATA)
 Location: BLM, Rock Springs, WY.
 Contact: Bruce Baker.
 Evaluation: Design: Raptor nest locations (legal descriptions)
 within T14N to T24N, R97W to R119W.
 Value to OIA Study: Location: Documented nest sites are within
 BRD study area. Further Study: These nest locations may
 be the same as those listed by WGFD 1977. Both sets of
 raw data need to be examined for duplication.
 Subjective Evaluation of Information: These nest sites, if
 not duplicates of WGFD data, could be used for future
 nest surveys.

USDI, Bureau of Land Management. 1978. Volume 2, site specific analysis - Draft Environmental Statement for proposed development of coal resources in southwestern Wyoming. Bureau of Land Management, Rock Springs District Office, Rock Springs, WY. (ANALYZED DATA)

Location: BLM, State Office, Cheyenne, WY.

Evaluation: Design: Description of existing environments, including surface water quality and stream flows, major vegetation types, game and nongame fish, nongame and game birds, nongame and game mammals, herpetofauna, and endangered and threatened species as well as present land uses are provided for the proposed North Block mine (T21N to T22N, R116W), Twin Creek mine (T21N, R116W), and South Haystack mine (T16N to T17N, R117W). Maps (scale 1" to 1 mile; resolution less than 40 acres) accompany proposed mine site sections and include vegetation types and animal distributions (big game ranges, sage grouse strutting grounds, and raptor nest locations). Environmental impacts of each proposed mine project on water, vegetation, and fish and wildlife resources are also discussed. Analysis Methods: Wildlife densities are given as estimates without documented field data. Acreage lost during progress of the respective mines and wildlife losses are likewise estimated.

Value to OIA Study: Location: These proposed mines lie in the Kemmerer Known Recoverable Coal Resource Area on the eastern boarder of the BRD study area. With mostly descriptive information on species likely to occur, this report has little value as baseline information source.

Subjective Evaluation of Document: Vegetation and wildlife information is discussed generally but no replicable data are presented for baseline use.

USDI, Bureau of Land Management. 1978. Appendix A, maps-Draft Environmental Statement for the proposed development of coal resources in southwestern Wyoming. Bureau of Land Management, Rock Springs District Office, Rock Springs, WY. (MAPPING)

Location: BLM, State Office, Cheyenne, WY.

Evaluation: Area Covered: Southwestern Wyoming. Scale: $\frac{1}{4}$ " to 1 mile. Resolution: Less than one square mile. Ground Truthed: Unknown. Information Mapped: Three maps are of interest: Map 7: General vegetation distribution showing grassland, meadow, sagebrush, mountain shrub, conifer with forage, barren, juniper, aspen, saltbush, greasewood, cropland, and riparian/other broadleaf types. Map 8: Wildlife distribution showing mule deer range, mule deer crucial winter range, pronghorn crucial winter range, elk range, elk crucial range, moose summer range and moose crucial winter range. Map 8a: Wildlife distribution showing sage grouse strutting ground and breeding complexes, sage grouse crucial nesting areas, raptor nesting areas, white-tailed prairie dog concentrations, and sage grouse range.

Subjective Evaluation of Maps: All maps have low level of

USDI, Bureau of Land Management 1978, cont.

resolution but provide large area indications of species or habitat presence. Wildlife information mapped is from WGFD and there are no indications of ground truthing. Maps have little potential for use in impact assessments.

USDI, Bureau of Land Management. 1979. Kemmerer Resource Area oil and gas leasing environmental assessment record. Bureau of Land Management, Rock Spring District Office, Rock Springs, WY. (ANALYZED DATA)

Location: BLM, State Office, Cheyenne, WY.

Evaluation: Design: Description of existing environment within the Kemmerer Resource Area includes vegetation types and livestock potential production/use, lists of plants found in common vegetation types, listing of noxious weeds and threatened or endangered plants, threatened or endangered birds and mammals likely to occur in the resource area, big game range occupancy and WGFD population estimates, listings of small game mammal, furbearers and rodents likely or known to occur, sage grouse habitat acreage, blue grouse, ruffed grouse and waterfowl occupied area acreage, other game bird, raptor, shorebird and small nongame bird listings, list of herpetofauna, streams in which treated, endangered, or sensitive fish species occur, list of fish species common to the area, Analysis Methods: Resource area acreage for different vegetation types, acreage for different noxious weeds, and tabular summaries of stream habitat inventories are quantitative data provided. Other information in the form of lists or discussed in the text. Maps (scale approximately 1:422,400) in text include oil and gas lease stipulations (big game critical winter range, elk calving areas, sage grouse nesting/strutting areas, sage grouse wintering complexes, Bear River Cutthroat trout areas, lambing areas and critical watersheds), vegetation types, wildlife crucial areas (big game, bald eagle, and sage grouse), and aquatic wildlife (Bear River and Colorado River cutthroat trout habitat).

Value to OIA Study: Location: The BRD study area is within the Kemmerer Resource area. Conclusions: Impacts due to oil and gas activities are discussed for livestock, vegetation, terrestrial and aquatic wildlife and mitigation/enhancement recommendations are provided in separate chapters. Summary of conclusions stresses that oil and gas development is not compatible with wildlife land uses.

Subjective Evaluation of Document: Specifies oil and gas development activities and expected impacts on wildlife, but no quantitative data are presented to be used as baseline or existing information against which actual impacts may be measured.

USDI, Bureau of Land Management. 1979. Thomas Fork habitat management plan. Bureau of Land Management, Rock Springs District Office, Rock Springs, WY. (ANALYZED DATA)

Location: BLM, Rock Springs, WY.

Evaluation: Design: Management objectives, planned actions and proposed interagency coordination of timber, livestock grazing, recreation, watershed and water quality, mineral development, and fire management in the Thomas Fork area for the immediate protection of genetically pure populations of Bear River cutthroat trout. Analysis Methods: Grazed and ungrazed riparian area comparisons show high degrees of livestock forage utilization. These data are tabulated as are soil compaction comparisons between different sources, soil moisture for different soils, utilization studies on Huff Creek, and summarized stream habitat data for the Thomas Fork drainage.

Value to CIA Study: Location: Thomas Fork habitat area is north of the BRD study area, T26N to T28N, R118W to R119W.

Conclusions: Proposed actions to insure survival of the Bear River Cutthroat gene pool include stream bank protection (fencing), stream habitat improvement (aspen and willow plantings, drop structure and rip-rapping erosion area projects), riparian utilization livestock enclosure studies, grazing use adjustments, instream flow needs for Bear River cutthroat, land re-classification, and road maintenance (culvert improvements, surface upgrading, vegetation stabilization of slopes). These management procedures, if successful, could be applied to streams in need of improvement in the BRD study area. Further Study: This project is continuing.

Subjective Evaluation of Document: The BRD is south of this habitat management area. Relevant procedures are applicable to the BRD area and could be employed as mitigation/enhancement projects in the future.

USDI, Bureau of Land Management. 1980. Aerial photographs.

Source: Bureau of Land Management.

Location: BLM, State Office, Cheyenne, WY.

Contact: Bruce Keating.

Evaluation: Area Covered: Uinta and Lincoln Counties, T13N to T23N, R112W to R121W. Scale: 1:24,000. Type: Dual camera natural color and color IR.

USDI, Bureau of Land Management. 1980. Final environmental assessment, Whitney Canyon and Carter Creek natural gas processing projects. Bureau of Land Management, Rock Spring District Office, Rock Springs, WY. (ANALYZED DATA)

Location: BLM, State Office, Cheyenne, WY.

Evaluation: Design: Description of affect environment includes big game crucial habitat (primarily mule deer and pronghorn) sage grouse strutting ground/nesting complexes, threatened and endangered species (including potential occurrence of

USDI, Bureau of Land Management 1980, cont.

peregrine falcons and black-footed ferrets and a brief discussion of bald eagle use of the Woodruff Narrows area), fish present in the Bear River and intermittent tributaries. Environmental impacts due to proposed processing plants and ancillary facilities on vegetation, big game, sage grouse and wintering bald eagles as well as stream habitats are briefly discussed. Mitigation plans to alleviate or reduce environmental consequences of the projects and anticipated effectiveness are tabulated. Analysis Methods: No quantitative data are presented. Important wildlife areas (including golden eagle nests, bald eagle roosting areas, crucial big game winter ranges and sage grouse nesting/strutting ground areas) are mapped. Otherwise, wildlife occurrence is descriptive.

Value to OIA Study: Location: The gas processing plants are within the BRD study area. Conclusions: Acreage lost to wildlife (big game and sage grouse) are tabulated for the proposed projects. Mitigation measures and enhancement projects are recommended beyond those specified in the permit application.

Subjective Evaluation of Document: Although no specific data are provided that could be used actual impact analysis a number of valid mitigation measures are suggested and could be implemented in the future.

USDI, Bureau of Land Management, 1981. Draft sulfur transportation supplement to the Whitney Canyon-Carter Creek natural gas processing projects. Bureau of Land Management, Rock Springs District Office, Rock Springs, WY. (ANALYZED DATA)

Location: BLM, State Office, Cheyenne, WY.

Evaluation: Design: Description of affected environment includes listing of threatened plants, big game winter area descriptions, sage grouse strutting ground/nesting complexes, raptor nest sites (golden eagle and prairie falcon), potential peregrine falcon and black-footed ferret occurrence and bald eagle wintering areas nearby. Analysis Methods: Important wildlife use areas are mapped (prairie falcon and golden eagle nest locations, sage grouse nesting and strutting grounds, and crucial big game winter range). Acreage lost by various sulfur transportation alternatives is tabulated as well as acreage of floodplain and riparian habitat disturbed, wildlife habitat disturbed and estimated animals lost per alternative.

Value to OIA Study: Location: The sulfur transportation alternatives are within the BRD study area. Conclusions: Mitigation recommendations supplement those in the 1980 EA.

Subjective Evaluation of Document: See USDI 1980 EA, above.

USDI, Bureau of Land Management. 1982. Range site examination, Cumberland Allotment. Unpublished data, Bureau of Land Management, Kemmerer Resource Area Office, Kemmerer, WY. (RAW DATA)

Location: BLM, Kemmerer, WY.

Contact: Pat Netherly.

Evaluation: Design: Sixteen transects in various vegetation types were sampled with ten plots per transect. Data include weight estimates by plant species, species density, frequency, percent cover, age class, and phenology. Livestock distribution and bird sightings were recorded concurrently. Timing: 1983 plans include mapping the Cumberland Allotment for range sites and soils.

Value to OIA Study: Location: the Cumberland Allotment is within the BRD study area. Further Study: Raw data needs to be examined for variance and sample size adequacy. Additional sampling effort within and outside the Cumberland Allotment may be necessary.

Subjective Evaluation of Information: Potentially useful data for eventual use in more comprehensive habitat inventories involving the entire BRD study area.

USDI, Bureau of Land Management. 1982. Vegetation cover maps. Work in progress, Bureau of Land Management, Rock Springs District Office, Rock Springs, WY. (MAPPING/RAW DATA)

Location: BLM, Rock Springs, WY.

Contact: Ann Alfredge.

Evaluation: Area Covered: North of highway US 30, west to Dempsey Ridge, east to Commissary Ridge, north to USFS boundary. Scale: 1:24,000. Resolution: Less than 20 acres. Ground Truthed: Ten percent of total area mapped.

Information Mapped: Vegetation sites of comparable species and structural composition. Data gathered during ground truthing include basal cover on low shrubs and forbs, canopy cover for trees and high shrubs, soils information (depth, surface pH, pH at 20", general texture, erosion present, exposure and slope). Sites were mapped on ortho-quads using aerial color and IR photography.

Subjective Evaluation of Map: This study, although mostly north of the BRD study area, will provide baseline information to judge future habitat losses with more accuracy than can be done at present. The study may continue and should involve the BRD study area for present habitat inventories. These vegetation data should be very useful for incorporation with wildlife distribution information once available.

USDI, Bureau of Land Management. n.d. Overlay: oil and gas stipulations. Bureau of Land Management, Kemmerer Resource Area Office, Kemmerer, WY. (MAPPING)

Location: BLM, Kemmerer, WY.

Evaluation: Area Covered: Pioneer Trails Planning Unit.

Scale: $\frac{1}{2}$ " to 1 mile. Resolution: One square mile. Ground

Truthed: Unknown. Information Mapped: Avoidance areas, and

USDI, Bureau of Land Management n.d., cont.

dates include critical big game winter range (10/15-5/15), elk calving area (5/15-6/30), sage grouse nesting/strutting areas (3/1-6/15), sage grouse wintering complex (10/1-3/1), Bear River Cutthroat trout areas, lambing areas (5/1-5/31), critical watershed area, possible black-footed ferret habitat, bald eagle, golden eagle, prairie falcon nest and/or roost.

Subjective Evaluation of Map: Information provides locations of priority areas for future studies although quantitative data for impact evaluations have not been mapped.

USDI, Bureau of Land Management. n.d. Stream habitat inventories, Bear River, Blacks Fork and Hams Fork drainages. Filed data Bureau of Land Management, Rock Springs District Office, Rock Springs, WY. (RAW DATA)

Location: BLM, Rock Springs, WY.

Contact: Bruce Smith.

Evaluation: Design: Drainage summaries include number of streams on National Resource Lands and number surveyed, stream mileage by land ownership, channel stability ratings for miles surveyed, spawning habitat and resident habitat mileage and ratings on public land, habitat trend for mileage surveyed, riparian acreage and condition rating, beaver ponds inventoried. Also, stream by stream data includes ownership, miles inventoried, apparent stream habitat trend and channel stability, spawning and resident habitat with fisheries significance, riparian habitat acreage and condition rating, and beaver pond presence and description of status. Timing: Unknown whether follow-up or additional surveys are to be made.

Value to OIA Study: Location: Tributary streams to the Bear River, Blacks Fork and Hams Fork lie within or may originate in the BRD study area. Further Study: Follow-up surveys need to be conducted to evaluate present stream conditions. Streams included in these inventories need to be compiled with other stream inventory data (WGFD) for identification of overlap, supplemental and complementary information, and to identify streams or stream portions that are not inventoried.

Subjective Evaluation of Information: Potentially useful as baseline data if exact survey locations are known.

Whiskey Basin Consultants. 1982. Threatened and endangered plants inventory. Unpublished final report to Bureau of Land Management, Rock Springs District Office, Rock Springs, WY. (ANALYZED DATA)
 Location: BLM, Rock Springs, WY.
 Contact: Ann Aldredge.

Evaluation: Design: Four plant species, one listed as threatened and three as endangered or unknown status, were surveyed for density and population boundaries. Potential habitats for these plants were initially identified from aerial photos, geological maps, or in areas suspected to contain populations. Methods Analysis: Density estimates were determined for 6 populations of Physaria dornii, 9 populations of Physaria condensata, 1 population of Penstemon gibbensii, and 15 populations of Antennaria arcuata. Summaries of population site physical characteristics, vegetation types and plant associations as well the species biological and population characteristics are tabulated. Timing: Unknown if study is to be continued. Baseline: This information could be used as baseline information if the sites examined are to be disturbed in the future. Value to OIA Study: Location: Several sites examined are within the BRD study area. Conclusions: Management guidelines for protection of known populations are provided. Primary concerns center on livestock and deer grazing. Repeatability: All locations (legal descriptions) of known populations are described and maps provided. Study is replicable.

Subjective evaluation of Document: Valuable to OIA study should the question of rare, threatened or endangered plants become an issue. The study provides information useful in planning when new areas to be developed for oil and gas exploration and production are considered.

Wiley, R.W. 1972. Black's Fork River volume flow observations, Uinta County, Wyoming. Project 0472-08-6602. Unpublished report, Wyoming Game and Fish Department, Fish Division, Cheyenne, WY. (ANALYZED DATA)
 Location: WGFD, Cheyenne, WY.

Evaluation: Design: During 1971, stream flow data were obtained at four flow stations on Black's Fork downstream from Meeks Cabin Reservoir. Analysis Methods: Quantitative evaluation of stream coverage at three different flow levels and water depth at three stations for different flows. Photographic documentation of channel coverage at three flow levels. Timing: No further studies are anticipated.

Value to OIA Study: Location: Black's Fork is in the southeastern corner of the BRD study area. Conclusions: The effects of stream dewatering on trout habitat are discussed. With increase water demands for irrigation projects stream flow restrictions to 10 cfs are inadequate to sustain a trout fishery' on the upper Black's Fork, downstream from Meek's Cabin Reservoir. Further Study: No further study is anticipated on this stream but the study could be replicated elsewhere to determine minimum stream flows in other known or potential trout streams.

Subjective Evaluation of Document: A good experimental (manipulative) procedure for documenting stream characteristics under different flow regimes. The study itself is geographically peripheral to the BRD study area and offers little baseline data value.

Wrakestraw, G.F. 1970. Waterfowl status report.

Wrakestraw, G.F., L. Serdiuk, and R. Saul. 1971 and 1972. Waterfowl status reports.

Wrakestraw, G.F., R. Saul, and L. Serdiuk. 1973 and 1974. Migratory bird surveys.

Unpublished reports, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: The following information is contained in these annual reports: Duck breeding count data compiled for the entire state of Wyoming with comparisons for 3 previous years, Canada goose breeding pair survey listed for the Bear River area without more detailed count locations. 1973 and 1974 reports also provide counts of sandhill cranes along the Bear River in Lincoln County. Analysis methods; Data are summarized by state (for ducks) or for the Bear River survey area. Comparisons with past counts are provided.

Value to OIA Study: Location: Only Canada goose and sandhill crane counts are specific to the BRD study area. However, the specific areas surveyed are not given. Conclusions: These data are appropriate for use as trend information but, since the survey methods and areas covered are not given replicability is questionable.

Subjective Evaluation of Documents: Because they lack specificity, these reports have little utility for impact analysis.

Wyoming Game and Fish Department. 1957 to present. Fisheries management annual progress reports. Unpublished annual reports, Wyoming Game and Fish Department, Fish Division, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: Design: Fisheries projects for a given year within the BRD study area on Bear River drainages (reported by Pinedale Fisheries management crew 40) and on Green River drainages (reported by Green River Fisheries management crew 44). Legal description of projects are given, Projects include population estimates for game and nongame fish with descriptions of sampling techniques used, fishery type (basic yield, wild, etc.) and management suggestions, spawning operations, habitat alterations, habitat quality assessments, USFS cooperative native cutthroat trout study, involvement and records of industrial permits, discharge permits, waste pollution and spills, federal, state and private land use and water projects, stream dewatering and public relations efforts. Analysis methods: Varied, depending on project. Timing: Some projects are completed within one year, others are of longer duration.

Value to OIA Study: Location: Many streams in BRD study area have been the subjects of different reports. Further Study: To see what type of project has been conducted on a specific stream, annual reports for a given time period need to be reviewed. Much information within these reports is summarized within the Fish Division Stream-Lake-Reservoir-Farm Pond computerized data base.

Wyoming Game and Fish Department 1957 to present, cont.

Subjective Evaluation of Documents: These reports provide a variety of qualitative and quantitative information all of which needs to be examined for specific streams of interest. Management objectives and recommendations and fish population data have particular relevance to the BRD study.

Wyoming Game and Fish Department. 1957 to 1958. Cokeville deer and elk stomach sample observations. Filed data sheets, Wyoming Game and Fish Department, Green River District Office, Green River, WY. (RAW DATA)

Location: WGFD, Green River, WY.

Contact: Elaine Raper.

Evaluation: Design: Elk and deer harvested in the Cokeville area were necropsied, plant species found in stomachs were identified. Collection date and location of each animal harvested are given. Baseline data: These data represent only known information on deer and elk food analysis within BRD area. Small sample size limits usefulness as baseline information and no data on food availability are provided.

Value to OIA Study: Location: Area from which samples were taken is north of the BRD study area. Further Study: The information is unique to the region although considerably out of date. Food and feeding habits studies for big game species need to be developed in the context of food availability. The raw data do not afford this type of examination.

Subjective Evaluation of Information: Data of little or no use due to location, limited sample size, no methods given on plant remains identification techniques, timing, and no opportunity to evaluate food availability. Since the data represent only known source of deer and elk food information, they could be examined for between animal and between species variation for future sample size determination if similar studies are to be conducted.

Wyoming Game and Fish Department. 1966. Black bear harvest and sightings. Filed data sheets, Wyoming Game and Fish Department, Green River District Office, Green River, WY. (RAW DATA)

Location: WGFD, Green River, WY.

Contact: Elaine Raper.

Evaluation: Design: Black bear age, sex and location of kill sites within District IV on hunter harvest forms.

Value to OIA Study: Location: Documented sightings north of BRD study area. Only value of information is confirmation of black bear occurrence in BRD vicinity.

Subjective Evaluation of Information: Verifies black bear occurrence in region. Otherwise the information has no baseline value.

Wyoming Game and Fish Department. 1958 to 1963. Elk tag returns, Cokeville area. Filed data sheets, Wyoming Game and Fish Department, Green River District Office, Green River, WY. (RAW DATA)

Location: WGFD, Green River, WY.

Contact: Elaine Raper.

Evaluation: Elk tagging locations, dates tagged, sex and age of animals and tag numbers. Tagging locations compared with location of kill sites, whether hunter or vehicle related.

Wyoming Game and Fish Department 1958 to 1963, cont.

Value to OIA Study: Location: Cokeville area, north of BRD study area. Further Study: These data need to be compiled with other data appearing in spot or job completion reports to see if duplication or overlap exists. Mapping of capture and kill locations will provide a rough analysis of elk movements.

Subjective Evaluation of Information: These data when compiled with other, similar information can provide gross movement patterns of elk. However, two known points in an animal's life movements has limited utility in impact evaluation.

Wyoming Game and Fish Department. 1970, 1971, 1977. Lincoln elk tagging study. Filed data sheets, Wyoming Game and Fish Department, Green River District Office, Green River, WY. (RAW DATA)
Location: WGFD, Green River, WY.
Contact: Elaine Raper.

Evaluation: Design: Elk tagging near Fontennelle Creek, LaBarge Creek, and from Commissary Ridge to Smiths Fork. Trap or capture sites, sex, age, tag numbers and collar colors are provided.

Value to OIA Study: Location: North of BRD study area. Further Study: These tagging data need to be compiled with tagging data listed in other reports and files and examined for redundancy. Observations and hunter tag returns must be combined with tagging data so that gross movement patterns may be analyzed.

Subjective Evaluation of Information: As with all big game tagging data, relocations or hunter tag return locations only provide two points out of all movements during an animal's life. The information thus obtained has limited utility in impact evaluation.

Wyoming Game and Fish Department. 1972. Statistics of a one day fishing season on Kemmerer City Reservoir. Unpublished administrative report, Wyoming Game and Fish Department, Fish Division, Cheyenne, WY. (Analyzed DATA)
Location: WGFD, Cheyenne, WY.

Evaluation: Design: Results from fishing survey on the Hams Fork River providing fisherman numbers, harvest numbers, trout size, age composition and estimated standing crop. Species composition of other game and non-game fish in reservoir also give. Timing: No future work anticipated. Analysis methods: Summary tables, see categories under design, above.

Value to OIA Study: Location: Northwest of Kemmerer. Repeatability: Fishing survey is replicable. Further study: None recommended. The survey was limited in both time and geographical relevance.

Subjective Evaluation of Document: Because of limited geographical coverage, this information is not particularly useful as baseline data.

Wyoming Game and Fish Department. 1972 to 1975. Mule deer movement and distribution studies in the Lincoln Unit, District IV. Filed data sheets, Wyoming Game and Fish Department, Green River District Office, Green River, WY. (RAW DATA)
Location: WGFD, Green River, WY.
Contact: Elaine Raper.

Evaluation: Design: Mule deer trapping location, year tagged, and location of hunter harvest or road kill. Mapped locations (scale unknown) accompanies data and indicates movements on areas north of highway US 30 along Rock Creek Ridge and Dempsey Ridge.

Value to OIA Study: See WGFD 1958 to 1963, above.

Subjective Evaluation of Information: See WGFD 1958 to 1963, above.

Wyoming Game and Fish Department. 1975. Tag return data form deer tagged near Crawford Mountains. Filed data sheets, Wyoming Game and Fish Department, Green River District Office, Green River, WY. (RAW DATA)
 Location: WGFD, Green River, WY.
 Contact: Elaine Raper.
 Evaluation: Design: Mule deer trapping location, year tagged, tag numbers, and location of harvest are listed.
 Value to OIA Study: See WGFD 1958 to 1963, above.
 Subjective Evaluation of Information: See WGFD 1958 to 1963.

Wyoming Game and Fish Department. 1976 to 1978. Deer tagging data in hunt area 137 and for Fontenelle tagging project. Filed data sheets, Wyoming Game and Fish Department, Green River District Office, Green River, WY. (RAW DATA)
 Location: WGFD, Green River, WY.
 Contact: Elaine Raper.
 Evaluation: Design: Mule deer trapping locations, trap date, sex, age, ear tag numbers and collar codes.
 Value to OIA Study: See WGFD 1958 to 1963, above.
 Subjective Evaluation of Information: See WGFD 1958 to 1963, above.

Wyoming Game and Fish Department. 1977. Current status and inventory of wildlife in Wyoming. Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)
 Location: WGFD, Cheyenne.
 Evaluation: Design: Species by species accounts defining state wide abundance, population status, research/management priority rating and the following more specific information for wildlife groups: Nongame mammals: species distribution (by county or general geographic area in Wyoming) and general habitat type occupied; Same information for game mammals; Nongame birds: general habitat type, nest description, migration dates and A.O.U. number; Same information for game birds; Only abundance, population status and management priority given for herpetofauna; Same information for game and nongame fish with comments on distribution and introduction histories; Wildlife listed as rare in Wyoming are covered in more detail with respect to status, distribution and habitat.
 Value to OIA Study: Location: No specific information is presented beyond state-wide distributions or large geographical areas. Conclusions: No conclusions are presented except for management priority classes for each species. This information points out need for additional information on population status and distribution for many species.
 Subjective Evaluation of Document: A general reference document but no value for impact assessment.

Wyoming Game and Fish Department. 1977. Raptor nest locations and nest activity status. Filed data sheets, Wyoming Game and Fish Department, Green River District Office, Green River, WY. (RAW DATA)
 Location: WGFD, Cheyenne, WY.
 Contact: Elaine Raper.
 Evaluation: Design: Raptor nest inventory including the area within T14N to T24N, R97W to R119W. For each nest the following information is provided: occupying species, activity status, nest substrate, height, exposure of nest, vegetation type and major prey species in nest area. Photographs of nests are also on file.

Wyoming Game and Fish Department 1977, cont.

Value to OIA Study: Location: Area covered in inventory includes BRD study area. Further Study: These nest locations need to be mapped and combined with other known raptor nest sites from other sources so that areas that have not been surveyed can be defined. Follow-up nesting surveys for known nests are recommended. Subjective Evaluation of Information: Valuable information to be used in combination with other known nest sites for future nest surveys. No known follow-up surveys have been conducted for these nests since 1977. It is doubtful that one year's nest activity information can be used for adequate impact assessment.

Wyoming Game and Fish Department. 1978. A strategic plan for the comprehensive management of wildlife, 1978 to 1983. Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: Design: Wyoming Game and Fish Commission mandates by law; statewide overview of problems and potential strategies associated with wildlife management in Wyoming; State-wide and management district status, use, 1983 objectives, population and harvest statistics (1976 and projections to 1993) for each big game species; State-wide small game mammal and game bird 1983 objectives and harvest statistics (projected to 1993); Sport fisheries state-wide management plans and regional objectives for 1983; Additional management specifications are presented for furbearers, commercial fisheries, raptors, and non-licensed use of wildlife species.

Value to OIA Study: Provides management objects for various species on state-wide basis or, in the case of big game, within management districts. No specific information is presented for smaller geographic areas. Conclusions: Conclusions in the form of broad management problems and potential solutions are given for each species.

Subjective Evaluation of Document: Provides indications of management priorities, and long and short term objectives. Unfortunately, these are not described for small areas such as the BRD. Generally, the document provides a state-wide approach to wildlife management and area -specific needs may be inferred.

Wyoming Game and Fish Department. 1978. An analysis of the present and potential economic values of wildlife resources in southwestern Wyoming. Unpublished report, Wyoming Game and Fish Department, Planning Division, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: Design: Present and projected human population growth with concomitant 1993 expenditures for fishermen, and small game, upland game bird, waterfowl, black bear, antelope, mule deer, and elk hunter recreation in District IV. Analysis Methods: Projections are graphically represented for each game category based on past and present (1978) demands and projected human population growth in southwestern Wyoming. Timing: The projections may be updated in 1983.

Value to OIA Study: Location: Hunter and fisherman recreation use of wildlife is summarized for entire southwestern Wyoming, there are no breakdowns to smaller geographical units.

Conclusions: Demand for wildlife are expected to increase

Wyoming Game and Fish Department 1978, cont.

with decreasing supplies for some species. Further study; Similar information needs to be updated and produced for the BRD study area.

Subjective Evaluation of Document: Indicates economic value of wildlife and relative values for different wildlife categories. Useful for defining species priorities for research and mitigation projects if economic values are the only consideration.

Wyoming Game and Fish Department. 1978. South Haystack deer tagging study. Filed data sheets, Wyoming Game and Fish Department, Green River District Office, Green River, WY. (RAW DATA)

Location: WGFD, Green River, WY.

Contact: Elaine Raper.

Evaluation: Design: Mule deer trapping locations (mapped but scale unknown) near Haystack Draw and on the east side of Oyster Ridge. Sex, age, tag numbers and collar types are listed. Timing: February 1978. Not expected to continue.

Value to OIA Study: Location: Trapping done on east side of BRD study area. Further Study: As observations and harvest of tagged and collared deer become available this information needs to be compiled with capture site location for analysis of gross movement patterns within the BRD study area.

Subjective Evaluation of Information: Capture sites are near present oil and gas development areas in the BRD. Future observations of collared deer may provide information on some animals' movements. As with other tagging studies, movement information based on two location points has limited use in assessing impact.

Wyoming Game and Fish Department. 1979. Overlay: Prairie dog and black-footed ferrets. Wyoming Game and Fish Department, Cheyenne, WY. (MAPPING)

Location: WGFD, Cheyenne, WY.

Evaluation: Area Covered: State of Wyoming. Scale: 1:500,000. Resolution: One square mile. Ground Truthed: Assumed.

Information Mapped: Outlined sections known to contain white-tail prairie dog towns with notes on locations of black-footed ferret searches.

Subjective Evaluation of Map: Resolution is too gross to be used for site specific analysis. No quantitative evaluation of town size or occupancy is provided. Map does provide large area summary of prairie dog towns known in study area.

Wyoming Game and Fish Department. 1980. Overlay: Critical upland game bird habitats. Wyoming Game and Fish Department, Cheyenne, WY. (MAPPING)

Location: WGFD, Cheyenne, WY.

Evaluation: Area Covered: State of Wyoming. Scale: 1:500,000. Resolution: One square mile. Ground Truthed: Assumed.

Wyoming Game and Fish Department 1980, cont.

Information mapped: Point locations and surrounding areas of sage grouse and sharp-tailed grouse breeding complexes.
 Subjective Evaluation of Map: Resolution is gross but the overlay does provide the following sage grouse breeding complex locations within the BRD study area: eleven near the South Haystack mine area, ten on the west side of the BRD from Whitney Canyon to Sage Junction, one at Elkol, none south of I-80. These locations specify areas that have been surveyed for sage grouse leks. Whether other areas without breeding complexes have been tho roughly searched is unknown. No sharp-tailed grouse breeding complexes are indicated within or near the BRD study area.

Wyoming Game and Fish Department. 1981. Overlay: Buteo nest locations. Wyoming Game and Fish Department, Cheyenne, WY. (MAPPING)

Location: WGFD, Cheyenne, WY.

Evaluation: Area Covered: State of Wyoming. Scale: 1:500,000.

Resolution: One square mile. Ground Truthed: Assumed.

Information Mapped: Point locations (within one section) of known nests of red-tailed hawks, ferruginous hawks and Swainson's hawks.

Subjective Evaluation of Map: From the scale of the overlay it would be difficult to locate known nest sites. No nests are noted within the BRD per se, only red-tailed hawk nests are documented along highway US 30 and to the east of the BRD. Unlikely that the area has been completely surveyed.

Wyoming Game and Fish Department. 1981. Overlay: Falcon, accipiter, hawk and owl nest locations. Wyoming Game and Fish Department, Cheyenne, WY. (MAPPING)

Location: WGFD, Cheyenne, WY.

Evaluation: Area Covered: State of Wyoming. Scale: 1:500,000.

Resolution: One square mile. Ground Truthed: Assumed.

Information Mapped: Point locations (within one section) of known nests of prairie falcons, merlin, goshawk, Cooper's hawk, sharp shinned hawk, marsh hawk, osprey, great horned owl, burrowing owl, long eared owl, screech owl, great grey owl, and peregrine falcon habitat boundaries.

Subjective Evaluation of Map: From the scale of the overlay it would be difficult to locate known nest sites. Only two prairie falcon nests, south of the Haystack mine area, are documented for the entire study area. Unlikely that the area has been completely searched.

Wyoming Game and Fish Department. 1981. Overlay: Eagle nest and roost locations. Wyoming Game and Fish Department, Cheyenne, WY. (MAPPING)

Location: WGFD, Cheyenne, WY.

Evaluation: Area Covered: State of Wyoming. Scale: 1:500,000.

Resolution: One square mile. Ground Truthed: Assumed.

Information Mapped: Point locations (within one section) of known nests of golden eagles and bald eagles. Bald

Wyoming Game and Fish Department 1981, cont.

eagle roost sites are shown.

Subjective Evaluation of Map: Three golden eagle nests are shown along US 189 from I-80 north to Diamondville. One nest is located along US 30. No bald eagle nests are documented for the study area although winter roosts at Woodruff Narrows and on Rock Creek near Fossil Buttes National Monument are shown. No quantitative information on roost use is provided. It is unlikely that the study area has been completely searched for nesting golden eagles.

Wyoming Game and Fish Department. 1981. Overlay: 1980-1981 bobcat harvest. Wyoming Game and Fish Department, Cheyenne, WY. (MAPPING)

Location: WGFD, Cheyenne, WY.

Evaluation: Area Covered: State of Wyoming. Scale: 1:500,000. Resolution: One township (36 sq. mi.). Ground Truthed: Assumed. Information Mapped: Bobcat harvest within townships with numbers taken within that area from November 1980 to March 1981.

Subjective Evaluation of Map: The overlay shows the number of bobcats harvested within the BRD study area. The gross level of harvest locations can only provide relative importance of different areas for bobcat harvest. No information on harvest pressures on these townships or areas for which no harvest data are indicated is provided. The overlay needs to be updated annually to examine key bobcat areas.

Wyoming Game and Fish Department. 1981. Overlays: Big game DAUs for antelope, mule deer, elk, and moose. Wyoming Game and Fish Department, Cheyenne, WY. (MAPPING)

Location: WGFD, Cheyenne, WY.

Evaluation: Area Covered: Separate overlays for each big game species in the following DAUs: Antelope: Cedar Mountain, Carter Lease, and West Green River; mule deer: Uinta-Cedar Mountain, Carter Lease, and Wyoming Range; elk: Uinta-Cedar Mountain, Carter Lease, and West Green River; moose: Uinta-Cedar Mountain, Carter Lease, West Green River, and Lincoln. Scale: $\frac{1}{2}$ " to 1 mile. Resolution: Unknown, probably less than 40 acres. Ground Truthed: Unknown for all overlays. Information Mapped: Summer range, year round range, winter and critical winter range, and movement patterns for each species. Elk calving areas are shown where this information is known. Timing: Mapped information is composite of several years' observations. Seasonal ranges are updated as new information is gathered.

Subjective Evaluation of Maps: Useful for identifying general areas of concern, especially critical areas such as winter range and calving areas. Delineation of seasonal ranges and movement pathways are inferred from several years' observations of unmarked except for marked mule deer in the Wyoming Range DAU. These overlays are used to facilitate planning decisions related land use conflicts with industrial development.

Wyoming Game and Fish Department. 1981. Big game species data analysis unit herd status reports. Planning Division files, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)
Location: WGFD; Cheyenne, WY.

Evaluation: Design: Information relevant to BRD study area is contained in the following DAU files by big game species: Antelope: Cedar Mountain, Carter Lease (contains Cokeville-Sage job completion reports to 1981, before incorporation), and West Green River; mule deer: Uinta-Cedar Mountain, Carter Lease, and Wyoming Range (contains portions of the Carter Lease, West Green River, Sublette, and Lincoln mule deer DAUs through 1981 reorganization); Elk: Uinta-Cedar mountain, Carter Lease, and West Green River; Moose: Uinta-Cedar Mountain, Carter Lease, Lincoln, and West Green River. Each file contains the following information sections: 1) Management objectives projected to 1986 (herd population levels, harvest, recreation days, hunter density, success rate, number of hunters, days/animal taken, occupied habitat). 2) ONEPOP computer simulation model for herd unit population and sex/age ratio projections (only available for DAUs having an adequate data base). 3) General habitat/vegetation type descriptions for the DAU area. 4) Land occupancy statistics. 5) Seasonal range distribution maps reduced from $\frac{1}{2}$ " to 1 mile overlays. 6) Herd unit consumptive/economic value summaries 7) Hunt season structure summaries for 1971 to 1981. 8) Harvest statistics for 1971 to 1981. 9) Annual population investigation job completion reports for 1976 to 1981. 10) Land owner damage claims and WGFD actions taken. 11) Old data and other miscellaneous informations. Analysis methods: Varied, depending on section. Quantitative information is summarized for the entire DAU. Timing: Ongoing. Baseline data: As discussed for different job completion report citations, there is little site specific data contained in these reports that could be used as baseline, pre-impact information. The DAUs are managed on large area basis and require trend data, not specific distributions, movement dynamics, etc.

Value to OIA Study: Location: Portions of the BRD study area are included within the various DAU boundaries. Conclusions: Within each DAU file, a wide range of problem areas and strategies are listed with respect to land use conflicts, informational needs, and achievement of management goals. These are useful in specifying specific projects for future work. Further Study: Information is added to these files annually. The harvest statistic summaries, consumptive/economic values, population and productivity trend data, etc. are used to formulate and update WGFD short and long term management objectives and priorities for a given DAU.

Subjective Evaluation of Information: Management recommendations and trend information is valuable, but only for the geographical area the size of a given DAU. No specific information is provided for the BRD study area and interpolation is necessary to gain subjective descriptions of pre-development conditions. The broad nature of this information limits its usefulness for impact assessment.

Wyoming Game and Fish Department. 1981. Big game damage costs. Unpublished Planning Division report 5E, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: Design: Summaries of big game damage claim payments from 1974 to 1980 for antelope, mule deer, and elk in the Uinta-Cedar Mountain, Carter Lease, Cokeville (for antelope only) and the West Green River DAUs. Analysis Methods: Payments tabulated by year and species' DAU, annual damage costs estimates per animal in herd unit, average yearly damage payments for 1974 to 1980, and average big game DAU population estimates. Timing: Assumed further updated evaluations will be made. Baseline Data: The estimates for some of the parameters in the analysis are themselves based on estimates. Evaluations are summarized for large areas and represent gross trends over time that might be useful for identification of shifts in croplands use prior to and during industrial development.

Value to OIA Study: Location: Portions of the BRD study area are included in the various DAU boundaries. Conclusions: Damage claim trends may indicate needs for future herd reductions and reveal increased big game land use conflicts over time. The causes of these conflicts are unknown.

Subjective Evaluation of Document: Information contained in this report was compiled from appropriate sections in the big game DAU status reports. Its usefulness in describing pre-industrial development conditions is limited since summaries are for large areas and trends over time cannot be attributed to any specific cause.

Wyoming Game and Fish Department. 1981. Deer fawns and moose calf tagged on the Bear River Divide and mule deer telemetry data. Filed data sheets, Wyoming Game and Fish Department, Green River District Office, Green River, WY. (RAW DATA)

Location: WGFD, Green River, WY.

Contact: Elaine Raper.

Evaluation: Design: Five mule deer fawns and one moose calf were captured and tagged on the Carter Lease in June 1981. Sex and ear tag numbers are given. One doe mule deer was equipped with radio telemetry and some preliminary data analysis of relocations has been done. Timing: Unknown whether more deer are to be tagged in the future or if relocations of the tagged deer are available.

Value to OIA Study: Location: Capture sites are within the BRD study area. Further Study: Preliminary data analysis of the telemetry/deer's relocations indicates road avoidance (distance from road) as a function of roadside cover. More animals need to be radio telemetered and closely followed to evaluate the effects of disturbance. Relocations of tagged deer and moose need to be combined with capture locations for gross movement pattern analysis.

Subjective Evaluation of Information: This telemetry data set is unique in the study area. Further analysis needs to be done with the relocation information. However, no inferences and conclusions may be drawn with respect to the effects of disturbance on one deer's movement patterns.

Wyoming Game and Fish Department. 1982. Analysis of small game hunting statistics. Unpublished Planning Division report 6D, Wyoming Game and Fish Department, Cheyenne, WY. (ANALYZED DATA)

Location: WGFD, Cheyenne, WY.

Evaluation: Design: Changes in recreation day totals from 1973 to 1980 for different game species. Hunting statistics over time by different counties given for Canada geese, mourning doves, sage grouse, ruffed grouse, blue grouse, chukar, Hungarian partridge, cottontail, snowshoe hare, and red squirrel. Analysis Methods: Graphical displays of hunter numbers and number of recreation days for different species over time and projected to 1983. Timing: Assumed future updates will be made.

Value to OIA Study: Location: Lincoln and Uinta Counties are listed with other Wyoming counties. Conclusions: Comparisons to other counties can be made from tabulated data summaries. Graphs mostly show increased hunter demands over time for small game and game bird harvests statewide. Maps (scale unknown) show areas of expected concentrations of bird and small game hunters around major population centers including those in southwestern Wyoming.

Subjective Evaluation of Document: There is nothing specific to the BRD study area contained in this report beyond the county level. If expected trends in hunter use of small game and game birds continues, these species will demand more management attention and consideration for possible mitigation efforts.

Wyoming Game and Fish Department. 1982. Overlays: Areas of Canada goose distribution. Wyoming Game and Fish Department, Cheyenne, WY. (MAPPING)

Location: WGFD, Cheyenne, WY.

Evaluation: Six separate overlays. Area Covered: State of Wyoming. Scale: 1:500,000. Resolution: One square mile. Ground Truthed: Unknown and assumed, depending on overlay.

1. Title: Canada goose breeding grounds.
Information Mapped: Outlined areas of nesting areas and inventoried and non-inventoried breeding grounds. Areas are shown on Hams Fork and along the Bear River north to Star Valley.
2. Title: Potential Canada goose breeding areas.
Information Mapped: Outlined areas for potential breeding. No areas are shown in southwestern Wyoming or on the BRD.
3. Title: Canada goose molting areas, trapping/banding and release sites.
Information Mapped: Point locations (to nearest section) of banding and release sites and outlined molting areas. One trapping/banding site along Bear River northwest of Evanston.
4. Title: Canada goose nesting structure locations.
Information Mapped: Outlined areas of nesting structure locations. Areas shown include the Bear River, north and south of Cokeville, on Hams Fork and Lake Viva Naughton, and on Hams Fork near Opal.

Wyoming Game and Fish Department 1982, cont.

5. Title: Canada goose wintering areas, December 15 to March 1.
Information Mapped: Goose winter areas subject to freeze-up in most winters and winter areas not subject to freeze-up. No areas are shown in southwestern Wyoming and the BRD.
6. Title: Major Canada goose harvest areas.
Information Mapped: Outlined areas of Canada goose harvest. Major areas are near Evanston along the Bear River flood plains and along Hams Fork, north and south of Kemmerer.
Subjective Evaluation of Maps: These overlays, while on a large scale, point out the importance of the BRD study area to Canada geese for breeding and hunter recreation. No quantitative data are provided on the overlays. However, mapped areas may be used to identify sites for future habitat evaluations and habitat enhancement projects.

Wyoming Game and Fish Department. n.d. Stream surveys: Lincoln and Uinta Counties. Filed data cards, Wyoming Game and Fish Department, Fish Division, Cheyenne, WY. (RAW DATA)
Location: WGFD, Cheyenne, WY.

Contact: Mike Stone.

Evaluation: Design: Streams filed by county, each file entry includes some or all of the following information: stream name, tributary system, fish planting policy, annual creel reports, stream accessibility, occurrence of natural spawning, average water volume, fluctuations in volume, natural food grades, character of watershed, losses of fish, stream shelters, bottom characteristics, percent pools, riffles, presence of barriers, springs and diversions, water temperature, water chemistry, fish sampling methods, average mid-stream depth and average maximum depth, stream grade, vegetation present, pollution records and fish planting records. Timing: Information is updated as available.

Value to OIA Study: Location: Streams within the BRD study area are included within these files. Baseline data: Many streams have been surveyed prior to oil and gas development and several have been surveyed repeatedly. This information is potentially useful as baseline data. Further Study: A stream by stream examination is necessary to determine the nature of information available for a particular stream of interest.

Subjective Evaluation of Information: These files provide varying amounts of historical and present data that might be used for some aspect of impact assessment.

Wyoming Game and Fish Department. n.d. Lake surveys: Lincoln and Uinta Counties. Filed data cards, Wyoming Game and Fish Department, Fish Division, Cheyenne, WY. (RAW DATA)
location: WGFD, Cheyenne, WY.

Contact: Mike Stone.

Evaluation: Design: Lakes (ponds and reservoirs) filed by county, each file entry includes some or all of the following information: lake name, county, legal description, ownership, altitude, annual creel report, planting record, accessibility, tributary system, tributary streams, acreage, water fluctuation, natural or artificial, dams present, character of watershed,

Wyoming Game and Fish Department n.d., cont.

natural spawning, average depth, maximum depth and minimum depth, food grade, plants, pollution records and water chemistry. Timing: Information is updated as available.

Value to OIA Study: Location: Lakes within the BRD study area are included in these files. Baseline data: Many lakes were surveyed prior to oil and gas development and several have been surveyed repeatedly. These files contain some potentially useful information. Further Study: A lake by lake examination is necessary to determine the specific information available for any given lake.

Subjective Evaluation of Information: These files provide varying amounts of historical and present data that might be useful for impact assessment.

Wyoming Game and Fish Department. n.d. Stream-Lake-Reservoir-Farm Pond data base. Wyoming Game and Fish Department, Fish Division, Cheyenne, WY. (RAW DATA)

Location: WGFD, Laramie, WY.

Contact: Robert Wiley.

Evaluation: Computer printout provides the following information: Fisheries crew number (Pinedale area office crew 40, Green River area office crew 44), type of water (coded), drainage system code (Green River drainage is 4, Bear River drainage is 9), river section and water number codes, county code, name of stream, lake, reservoir or farm pond, range, township and section of the water, tributary system, stream esthetic code, road access to streams code, stream fisheries productivity code, combined esthetics, access and productivity code, standing waters acreage and stream mileage being documented and minimum acres or miles that will support a fisheries for the water, minimum pool required of standing waters and minimum flow (cfs) of streams, land status (ownership) of standing waters and streams, fisherman days estimates, management policy for up to five fish species, management concept (catchables, basic yield, trophy, unique species, or wild), management procedures and recommendation codes, habitat improvement recommendation codes, present fish species known in waters (for up to 30 species).

Timing: Information is updated as available.

Value to OIA Study: Most, if not all of the information appearing in this printout is listed in the stream and lakes survey files and annual project reports noted above. The value of this system is the concise nature of the compiled information.

Subjective Evaluation of Information: Many of the coded ratings are subjective but provide a relative scale for judging the importance of a particular stream. As with other raw data, the printout must be examined on a waters by waters basis to ascertain specific information and management policies available for a particular stream or standing water.

Wyoming Game and Fish Department. n.d. Wildlife observation system data base. Wyoming Game and Fish Department, Game Division, Cheyenne, WY. (RAW DATA)

Location: WGFD, Cheyenne, WY.

Wyoming Game and Fish Department n.d., cont.

Contact: Harry Harju.

Evaluation: Computer printout provides the following information for each observation of a given wildlife species: observation number, sequence code, management district number, information source, observation date, species code, number of animals observed broken down by sex and age categories or listed as unknown/unclassified, age if known, legal description and/or hunt area number or degree block locations, habitat type codes, mortality codes, and observer activity codes. Timing: Information is continuously being added to the data base.

Value to OIA Study: Location: Recently (March 1982) WGFD Green River District Office obtained a printout for all species observed within T12N to T18N and R117W to R121W. The number of species documented within this area includes the following: shorebirds, 6 species; waterfowl, 24 species; upland game birds, 2 species; raptors, 14 species; nongame birds, 59 species; nongame mammals, 13 species; small game mammals, 2 species; furbearers, 2 species; mustelids, 5 species; canids, 1 species; felids, 2 species; and ungulates (including feral horses), 5 species. Numbers of observations from 1976 to 1981 range from one for many species to over 900 for mule deer.

Subjective Evaluation of Information: Very likely many more observations are made than are recorded on this data base. Observations may be mapped for general distribution information but for most species there are not enough sightings to achieve this. Presently, the system has limited utility simply because there is insufficient information. However, the capability for requesting site specific information is available and could be quite useful in the future.

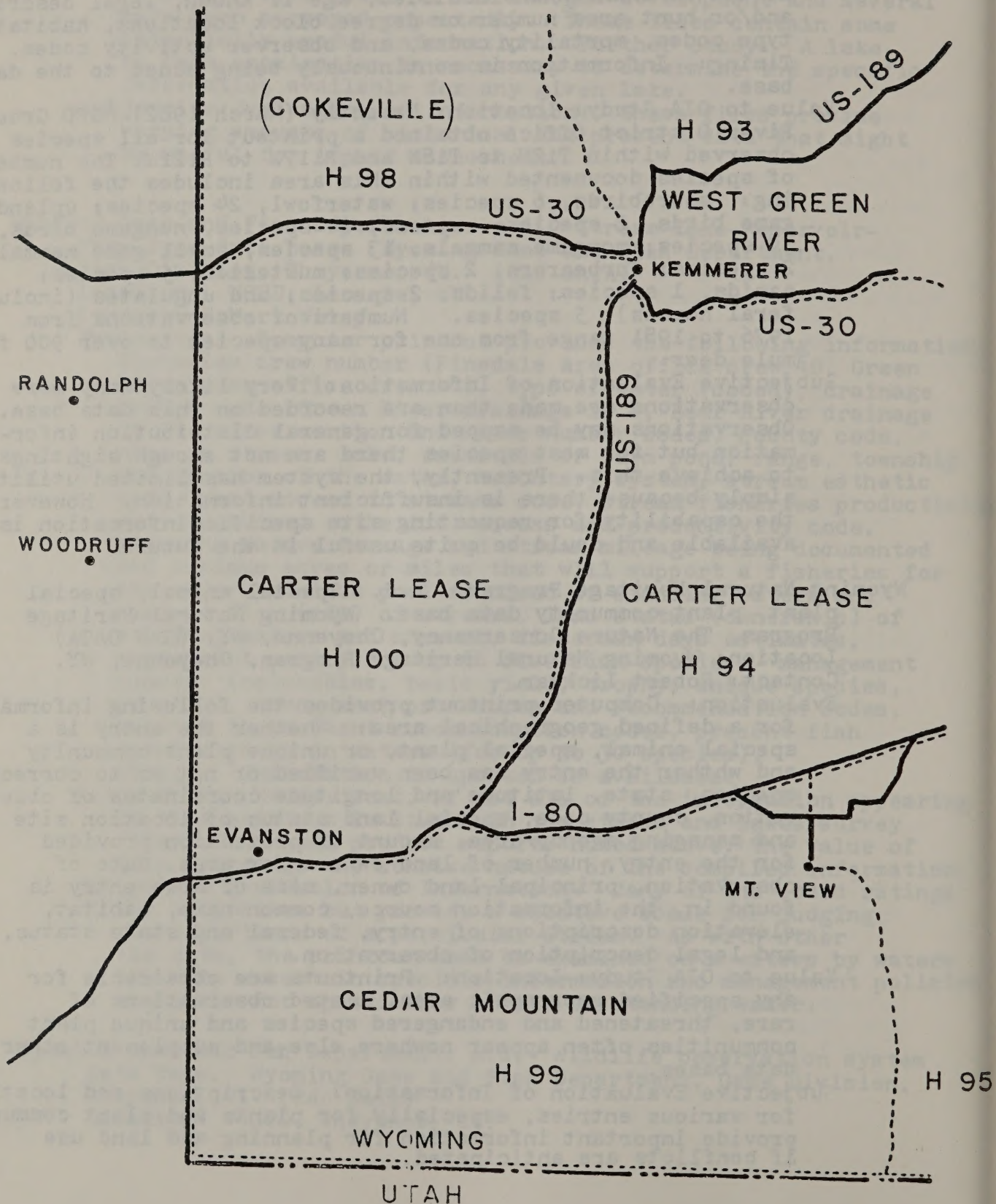
Wyoming Natural Heritage Program. n.d. Special animal, special plant, plant community data base. Wyoming Natural Heritage Program, The Nature Conservancy, Cheyenne, WY. (RAW DATA)
Location: Wyoming Natural Heritage Program, Cheyenne, WY.
Contact: Robert Lickvar.

Evaluation: Computer printout provides the following information for a defined geographical area: Whether the entry is a special animal, special plant, or unique plant community and whether the entry has been verified or not as to correct species, state, latitude and longitude coordinates of observation, county code, special land status of location site and managing agency/area, amount of protection provided for the entry, number of land owners for area, date of observation, principal land owner, size of area entry is found in, the information source, common name, habitat, elevation descriptions of entry, federal and state status, and legal description of observation.

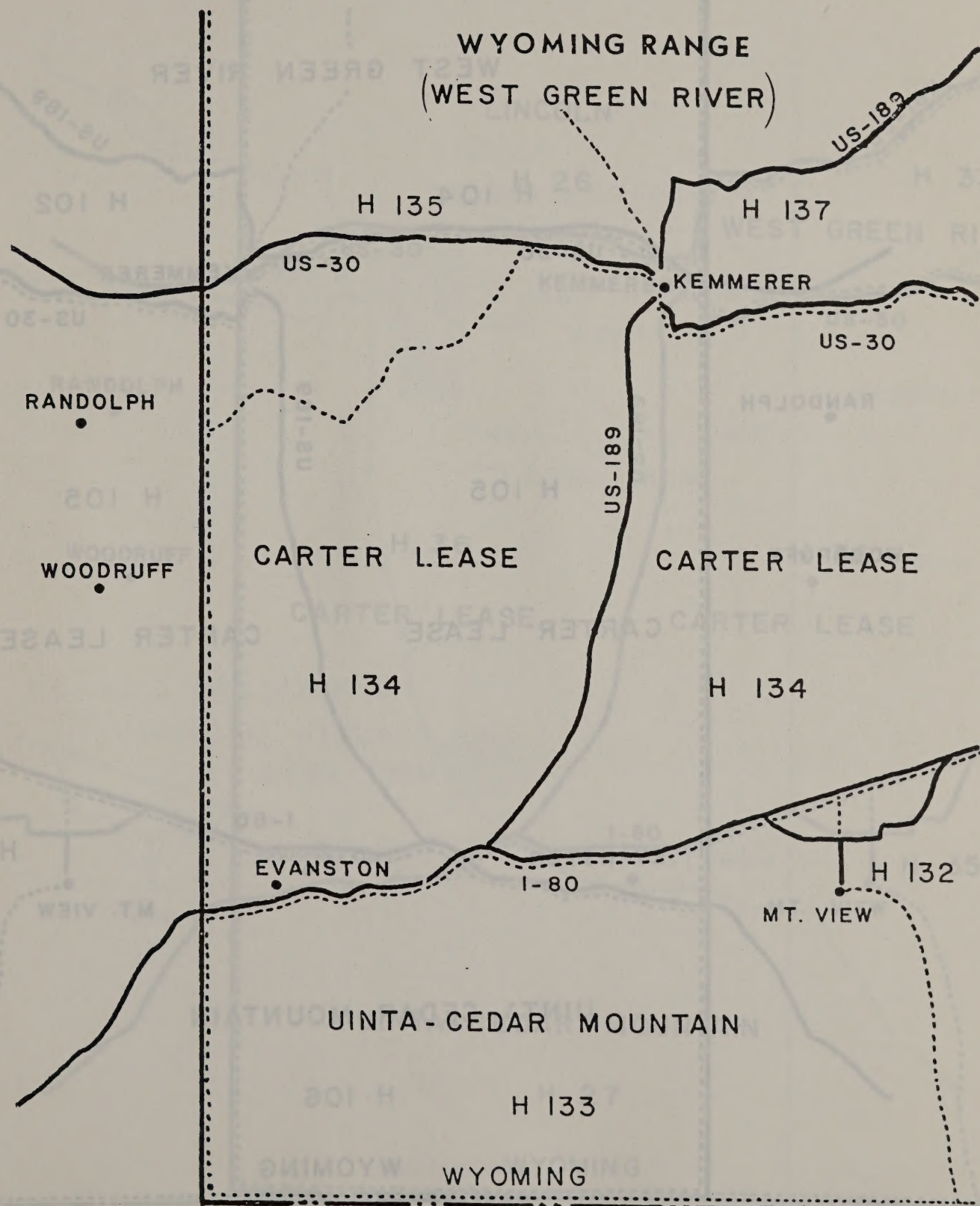
Value to OIA Study: Location: Printouts are obtainable for any specified geographic area. Listed observations of rare, threatened and endangered species and unique plant communities often appear nowhere else and supplement other data bases.

Subjective Evaluation of Information: Descriptions and locations for various entries, especially for plants and plant communities, provide important information for planning and land use if conflicts are anticipated.

Antelope Data Analysis Units in the Bear River Divide area. Dashed lines indicate hunt area boundaries (eg. H 98). In 1981 the Cokeville DAU was incorporated with the Carter Lease DAU. Seasonally used ranges and movement pathways are mapped (scale $\frac{1}{2}$ " to 1 mile) on overlays for each DAU and are on file at WGFD, Cheyenne.



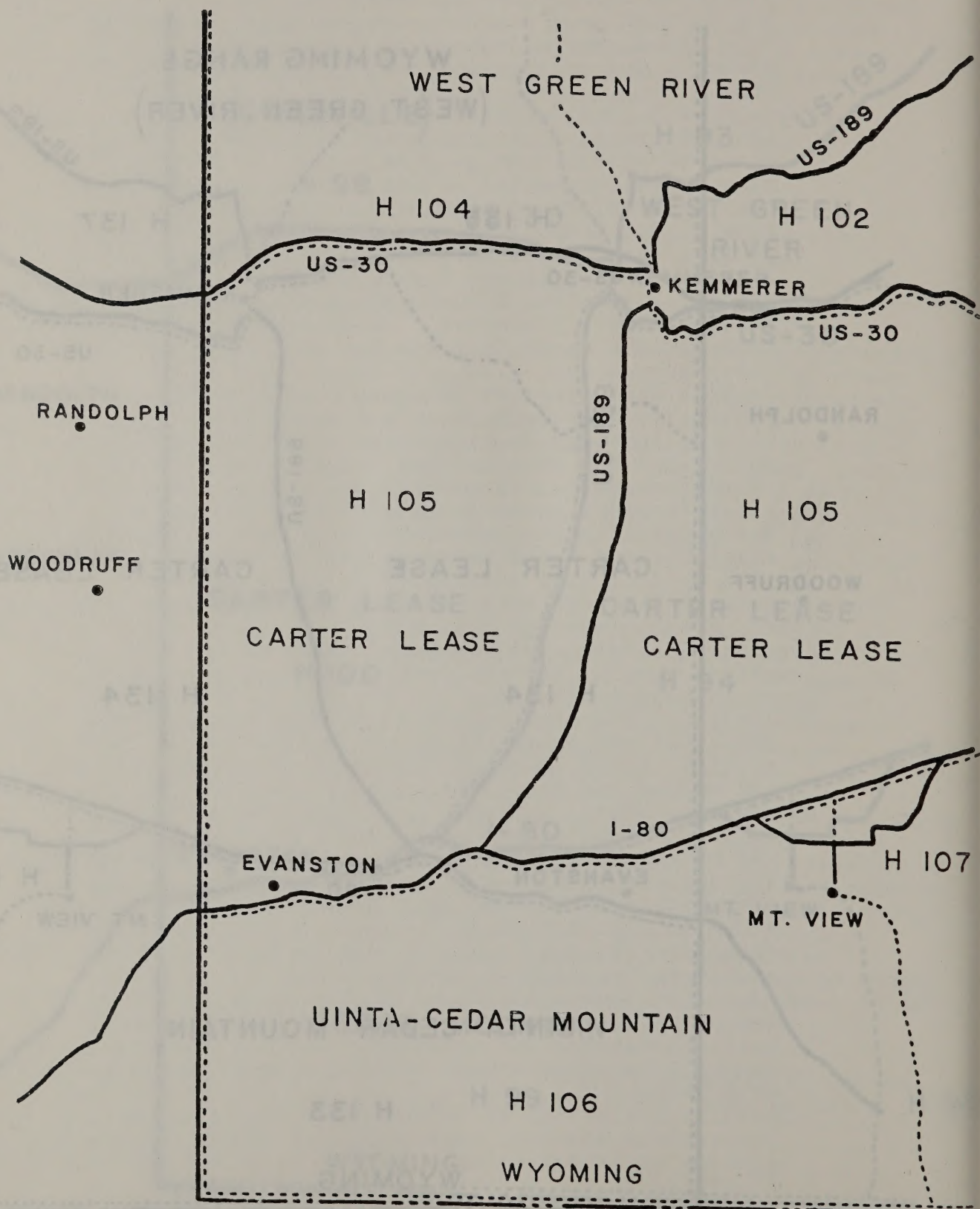
Mule deer Data Analysis Units in the Bear River Divide Area. Dashed lines indicate hunt area boundaries (eg. H 135). In 1981, the West Green River and northwest portion of the Carter Lease DAUs were incorporated into the Wyoming Range DAU. Seasonally used ranges and movement pathways are mapped (scale $\frac{1}{2}$ " to 1 mile) on overlays for each DAU and are on file at WGFD, Cheyenne.



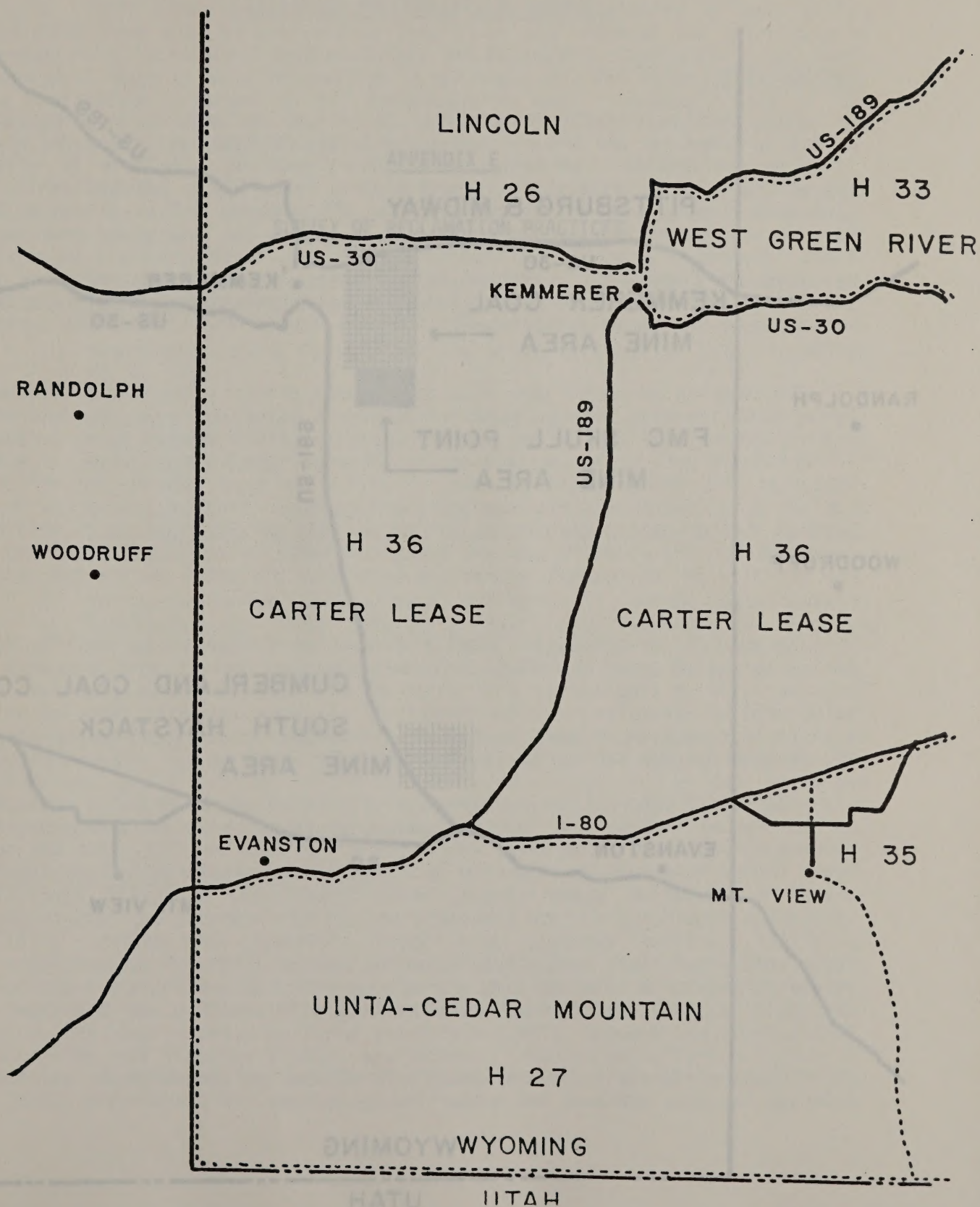
Elk Data Analysis Units in the Bear River Divide area.

Dashed lines indicate hunt area boundaries (eg. H 102).

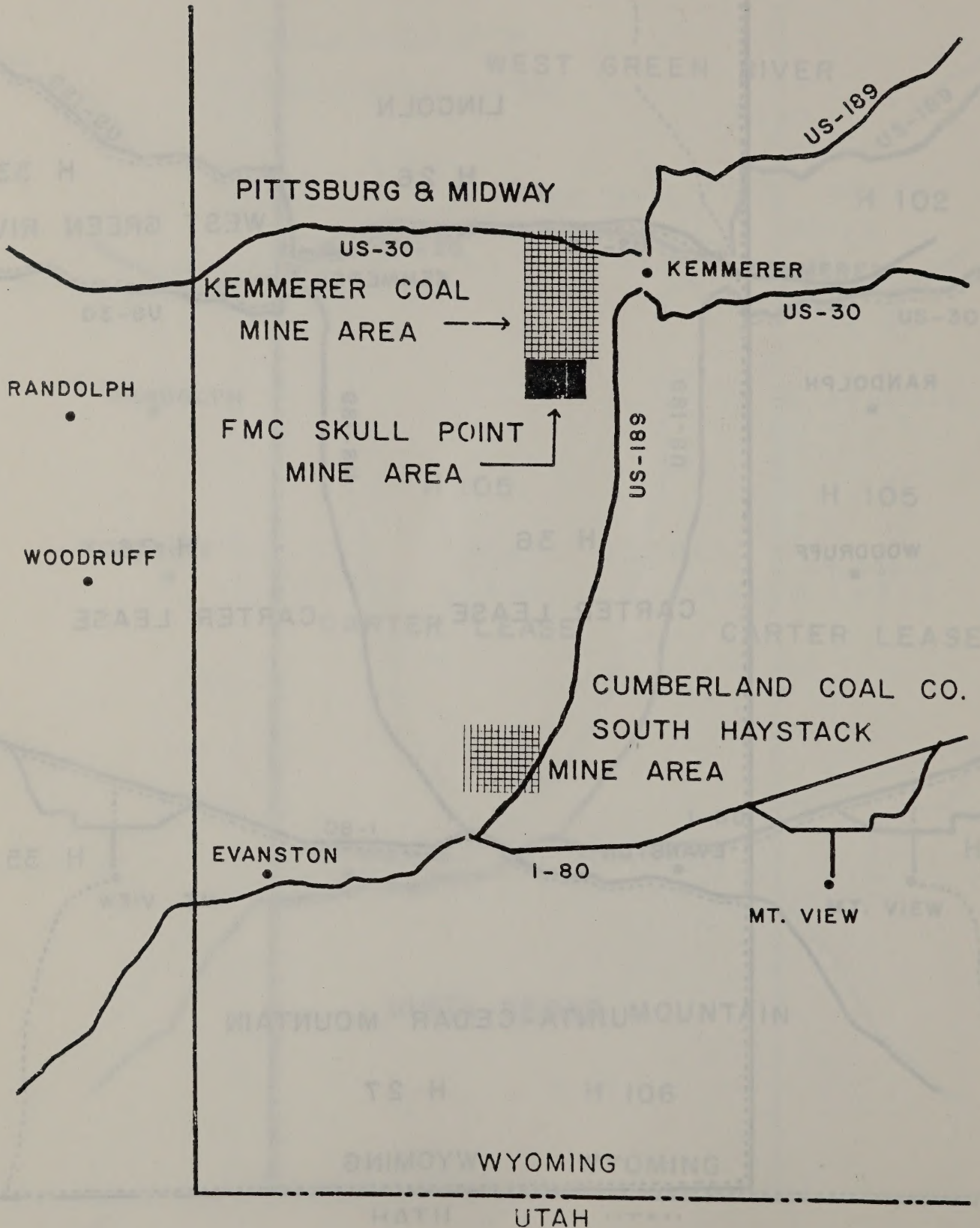
Seasonally used ranges and movement pathways are mapped (scale $\frac{1}{2}$ " to 1 mile) on overlays for each DAU and are on file at WGFD, Cheyenne.



Moose Data Analysis Units in the Bear River Divide Area.
 Dashed lines indicate hunt area boundaries (eg. H 26).
 Seasonally used ranges and movement pathways are mapped
 (scale $\frac{1}{2}$ " to 1 mile) on overlays for each DAU and are
 on file at WGFD, Cheyenne.



Locations of mapped information associated with coal mine related wildlife surveys. For descriptions of mapped information see the following sources: Berry 1982 (Cumberland Coal Company South Haystack Mine), Morrison-Knudsen Company 1981 (FMC Corporation Skull Point Mine), Stoecker 1981 (Pittsburg and Midway Coal Company Kemmerer Mine).



SURVEY OF RECLAMATION PRACTICES

INTRODUCTION

This section presents descriptions of various reclamation practices used by mining companies and the oil and gas industry in Wyoming, Idaho, and Utah. Industry reclamation personnel were interviewed by telephone to assess approaches used in reclamation, revegetation, and wildlife habitat manipulation conducted as part of mitigation plans and programs and to determine the ways in which programs are monitored. Included in the interview were questions directed at practices of topsoil stockpiling, topsoil/subsoil separation, recontouring slopes and reapplied soils, slope stabilization, mulching and other soil stabilization measures, seedbed preparation and seeding practices, methods used for shrub establishment, and the use of fertilizers and irrigation.

Reclamation personnel were also asked about projects specifically related to wildlife habitat manipulation. Questions were designed to determine whether habitat and vegetation diversity on reclaimed areas are being pursued, if nesting structures are being used for waterfowl and birds of prey, if water resources are being developed, and if any other types of on- or off-site habitat enhancement projects are being undertaken. Finally, inquiries about program monitoring and evaluation were made. The processes by which erosion, revegetation, and wildlife use are being monitored in reclaimed areas and in the vicinity of development operations were also discussed during the interview.

No specific practices are identified with or attributed to specific companies contacted in this survey. However, summary tables were prepared to provide relative frequencies with which particular reclamation practices are being used or attempted by these companies. Because companies reported using several different techniques or had done nothing, percentages may not total 100 percent for any particular category of procedures.

Additional information on current practices and research being conducted by the mining industry or industry sponsored projects is on file with the Wyoming Mining Association (WMA) in Cheyenne. In 1980 and 1981, the WMA surveyed member companies to identify and summarize research being done in the areas of vegetation establishment, weed competition, microbial symbiosis, vegetation inventory, surface treatment and seedbed preparation, topsoil manipulations, erosion control, mine spoil treatment, irrigation, wildlife use of reclaimed lands, and wildlife habitat manipulation. Brief abstracts of studies are on file with WMA but are not available to non-member individuals and organizations. No further details of this information are presented in this section.

Further information on reclamation practices and research in northwest Colorado has been reviewed and summarized by Redente and Grossnickle (1982) as

part of the Northwest Colorado Wildlife Consortium's evaluation of impacts due to various mining activities (see Task 2 Introduction). Redente and Grossnickle (1982) summarized changes in land use and vegetation of each mining operation from pre- to post-mining conditions and reviewed the literature on revegetation techniques, seed mixtures, and management strategies in northwest Colorado. Much of this information is site-specific but potentially valuable to reclamation programs in the intermountain West. However, many of the primary sources cited in the review are published as in-house reports and consultant reports with limited distribution.

The Wyoming Department of Environmental Quality (WDEQ), Land Quality Division, has prepared several guidelines for the mining industry in Wyoming. Pertinent guidelines cover recommended procedures for evaluating:

1. topsoils and overburden characteristics, removal, storage, and replacement (WDEQ Guideline No. 1, 1981);
2. vegetation before disturbance and after reclamation (WDEQ Guideline No. 2, 1981);
3. wildlife occurrence, habitat affinity, water quality before and after disturbances and evaluation of reclamation and wildlife mitigation plans (WDEQ Guideline No. 5, 1980, Revision 2);
4. surface waters, drainage, and aquifer characteristics prior to disturbances and estimations of impacts (WDEQ Guideline No. 8, 1980, Revision 2);
5. surface disturbances on alluvial valley floors, damage assessments to croplands, and identification of hydrologic functions in alluvial valleys (WDEQ Guideline No. 9, 1981, Revision 3); fence construction guidelines to reduce wildlife conflicts (WDEQ Guideline No. 10, 1979, Revision 1).

These guidelines provide developers with formats and techniques for data collection, analysis, and reporting. While designed for the mining industry, the guidelines could provide direction and standardization for the petroleum industry as well. Where specific recommendations are applicable to topics discussed in this section they are noted.

REVEGETATION TECHNIQUES AND PRACTICES

Topsoil

Salvage of existing topsoil prior to development for eventual redeposition has become recognized as a beneficial practice in arid and semi-arid disturbed land reclamation. The considerable progress made in topsoiling technology has been reported by Barth and Martin (1982), Schuman and Power (1981), McGuinnies and Nicholas (1980), and others. Topsoiling offers a number of potential benefits to reclamation including provision of an improved growth

medium for revegetation, reduction of potential erosional susceptibility, provision of propagules and seed of native species, and improvement in the availability of essential symbiotic soil micro-organisms. For these reasons, WDEQ (Guideline No. 1, 1981) outlines procedures for soil surveys, mapping soils, and estimation of soil quantity (volumes) so that all suitable topsoils can be salvaged and soil characteristics can be evaluated for achieving specified land uses following mining.

Nearly all operators contacted in this survey indicated that some degree of topsoil removal, storage, and re-application were being conducted. Table E-1 summarizes the various topsoil salvaging programs being conducted by companies contacted in this survey.

Most company personnel acknowledge the importance of topsoil in establishing successful revegetation programs and recommend topsoil salvage and separation from less productive subsoils or horizons.

The amount of topsoil removed depends on availability. The length of time topsoil is stockpiled depends on the duration of surface disturbance and occupancy. Although many companies practice stockpiling for one to two years, there appears to be agreement that re-applied soils are more productive, both in terms of seeded plant species and native plant growth from dormant seed, when the time they are stockpiled is minimized. While some companies report topsoil stockpiled for ten years or more, others state that re-application of stripped soil is attempted as soon as possible. This may involve soil transportation and application at a site different from the removal site. In a few cases where stockpiling may be prolonged, topsoil has been seeded with mixtures of wheatgrasses, barley, sweet clover and/or alfalfa to deter erosion, decrease loss of microbial symbionts, and maintain nitrogen fixation. Where topsoil is in limited supply, some companies use all available soils to provide a thin layer on existing subsoils or spoils under the assumption that even a thin layer of topsoil is a better plant growth medium than the underlying material.

Studies conducted on topsoil application over retorted oil shales in northwestern Colorado indicate that the depth of soil cover can affect vegetative growth (Redente and Grossnickle 1982). Vegetative cover and production of seeded native and introduced grasses, forbs, and shrubs has been shown to increase with increasing depth of soil cover. However, Redente and Grossnickle (1982) report that native species developed more extensive root systems than introduced species and noted that sub-surface barriers to root penetration, such as retorted oil shale or rocks in general, are penetrated by roots of native species but not by introduced species. Thus, where topsoil is limited for reapplication on surface disturbances, the use of native species would appear to be the best approach to establishing vegetative cover on shallow soils.

TABLE E-1

**SUMMARY OF TOPSOIL STOCKPILING PRACTICES
CONDUCTED BY MINING AND PETROLEUM INDUSTRY COMPANIES**

Stockpiling Practice	Percent of Companies Engaged in Practice ¹
No topsoil stockpiling	20
Topsoil stockpiled but not separated from subsoils	13
Topsoil stockpiled and separated from subsoils	67
Duration of Topsoil Stockpiling	
Immediate reapplication	27
Stockpiling less than 1 year	20
Stockpiling less than 2 years	27
Stockpiling more than 3 years	27
Stabilization of stockpiled topsoil with vegetation	20

¹Percentages do not add to 100 percent.

Landform Reclamation

Prior to re-application of topsoil on disturbed sites, sub-soil materials are generally regraded to produce a topography that: 1) promotes landform stability by reducing erosion potential; 2) is integrated into local topographic and watershed configurations; and, 3) presumably provides a proper surface for proposed future land uses. Proper initial regrading of disturbed sites has been recognized as essential for success in succeeding phases of the reclamation process (Munshower 1982). Verma and Thames (1978) review regrading technology which can lead to slope stabilization and produce locally integrated surface hydrology. Landform design can lead to vegetative diversity on reclaimed areas. Wollenhaupt and Richardson (1982) recommend concave surfaces for shrub establishment since the establishment of hardwood shrubs is largely dependent on soil moisture and concave or convergent landscapes tend to concentrate water more than convex surfaces. This can be an important consideration if reclaimed areas are proposed for use as wildlife habitat. However, Munshower (1982) has noted that little emphasis has been placed on regrading practices which yield topographic features essential for wildlife use.

Wyoming DEQ Guideline No. 8 (1980, Revision 2) provides criteria for evaluating pre-development surface water hydrology and surface drainage systems, suitable water control methods, impacts on water resources, treatments of affected aquifers, and reclamation of drainages. Wyoming mine operators provide hydrological data in the appendices (D-5 and D-6) to their mine permit applications and reclamation plans.

Industry contacts report that topographic slope specifications on reclaimed areas vary with local terrain and permit conditions. Some companies strive to return slopes to original grades and contours which were defined during pre-mining site analyses. Most companies report creating slopes of 3:1 or less as the upper limit for reclaimed surfaces but maximum slopes range from 5:1 to 2:1. Several different practices have been used on particularly steep slopes to control erosion. Oil and gas companies in Wyoming's Bear River Divide have used jute netting tacked to soils to abate erosion. However, one industry representative commented that there appeared to be no difference in grass establishment between areas covered with jute netting and adjacent untreated areas. Ridges constructed along slope contours have been used on long slopes to reduce runoff velocity; contour furrowing on steep slopes produces similar results.

In general, roughened surfaces deter runoff and promote water retention. To this end, companies have deep-ripped subsoils and chisel-plowed applied topsoil, mixed rock with soils, and used various mulches as both anti-erosion and anti-evaporation measures. Landform irregularities such as water bars, diversion ditches, and contour furrowing and terracing have also been used to reduce runoff velocities and create areas where water may be absorbed by the soil. Further structural barriers to surface discharges include placing hay bales in gulleys, diversion of runoff to sedimentation ponds, and sedimentation dams in streams to act as sediment traps.

Since industries contacted in this survey operate mines in areas where the precipitation varies from 6 to 18 inches annually and the soils and subsoils are highly variable, it is not possible to evaluate the relative effectiveness of these various erosion control measures. Site characteristics such as precipitation, evaporation, soils, underlying materials, and the nature of the disturbance all determine which measure(s) are most useful. Table E-2 summarizes the methods that industry has explored to control erosion and shows the relative frequencies with which these methods have been used by the companies contacted.

Seedbed Preparations

Almost without exception, water availability is the factor that limits reclamation in the arid and semi-arid west (May 1975, Hodder 1978, Monsen and Plummer 1978). Landform stability (discussed above) and soil stability are integral parts of water conservation procedures. Macro-scale surface modifications are usually implemented during regrading to produce such gross surface modifications as terraces, swale contouring, and contour trenches. Wright (1976), Hodder (1977), and Verma and Thames (1978) provide reviews of such methods. Micro-scale surface modifications such as pitting, contour furrowing, contour chisel plowing, and micro-imprinting are usually made after regrading. The net effect of these methods is to produce a roughened surface enhancing water retention, seed germination, and vegetative growth. Mulches also provide soil stabilization and a wide variety of mulch treatments have been reviewed (Kay 1978) and used by companies contacted in this survey. Mulches may be organic (wood fiber hydromulch, wood residues, crimped hay/straw, standing stubble) or inorganic (rock, sand). Table E-3 provides a summary of company use frequencies of different mulches and surface preparations. Usually, combinations of surface preparations and mulches were reported.

In every instance, subsoils or soils to be seeded are ripped or harrowed to produce a roughened surface. Some companies practicing topsoil stockpiling may deep-rip spoils or compacted materials prior to topsoil reapplication whereas others will disk harrow or shallow rip after topsoils have been spread. Although one company compacts backfilled materials, presumably to avoid subsidence of replaced spoils, the general practice is to avoid soil compaction. To this end, one operator suggests using tracked vehicles rather than equipment with tires during spreading and ripping operations. Track-mounted equipment spreads vehicle weight over a larger area and reduces point-contact compaction.

Various organic mulches have been used. Problem slopes have been treated with jute matting, discussed above. Blown and tacked straw hay mulch and hydro-mulches have also been used with mixed results. One reclamation specialist cautions use of hay or straw mulches in dry regions (less than 8 inches annual precipitation) since the mulch tends to adsorb water, making it inaccessible to seeds or plants. Another operator suggests that straw mulches are sources of weeds and should be avoided. Evaluations of hydro-mulch have not been very positive. One contact reported that hydro-mulch deteriorates by

TABLE E-2

**EROSION CONTROL MEASURES USED BY MINING AND PETROLEUM
COMPANIES IN WYOMING, IDAHO, AND UTAH**

A. Erosion Control Through Slope Minimization

Original Contours	Slopes to			
	More Than 2:1 max	2:1 max	3:1 max	Less Than 3:1 max
40%	7%	7%	40%	27%

B. Land Form Erosion Control Measures

Water Bars	Diversion Ditches	Contour Furrows	Terracing
13%	13%	7%	13%

C. Soil Surface Erosion Control Treatments

Fiber Netting	Tacked Surface Mulches	Crimped Stubble Mulches	Rock Mixed With Soils	Deep Rip/ Chisel Plow
27%	60%	40%	7%	40%

D. Structure Barriers to Erosion Discharges

Hay Bale In Drainage	Sedimentation Ponds	Stream Sediment Dams	Wind Fence
13%	27%	20%	7%

TABLE E-3

SUMMARY OF SEEDBED PREPARATION AND PROTECTION MEASURESA. Micro-Surface Preparations

Deep Rip Prior to Topsoil Application	Chisel Plow Graded Topsoils	Disk-Harrow Graded Topsoils	Micro- Imprinting
33%	27%	33%	7%

B. Organic Mulches

Wood Fiber Hydromulch	Excelsior/ Jute Mesh	Blown and Tacked Straw	Crimped Straw	Annual Grain Stubble	Native Hay
40%	27%	20%	33%	40%	27%

C. Inorganic Mulches

Rock	Washed Sand
7%	7%

the time seed germinates and thus cannot provide an effective evaporation barrier. Hydro-mulch used on spoils reclamation resulted in poor vegetation cover, according to another operator. Hydro-mulch is also expensive and requires transport access to the application site, thus negating soil decomposition efforts.

Several company personnel endorse the use of crimped native hay mulches which have the advantage of being relatively weed-free and providing a seed source of native species. Barley or other annual grain stubble mulch has also provided positive results and, if applied with fall seeding, contributes to spring growth and generation of plant cover. Others report stubble mulching in spring and drill-seeding through the stubble in fall. Because of its dependence upon rainfall, success requires that seed and mulch be in place and ready for germination during the wettest period, most often spring. If establishment of a pioneer or companion stubble mulch crop proves climatically feasible, several operators agree that stubble produces more positive effects than hay/straw mulches. To this end, one reclamation specialist reports using annual seedings of barley and millet to maintain cover and allow slower growing native grasses, forbs and shrubs time to become establishment in a favorable micro-environment.

Inorganic mulches reported include rock and sand. In one area where rock is abundant, it has been used to advantage by the operator. Rocks mixed with soils decrease runoff, acting as water and seed traps. A novel method for dealing with low precipitation and clay and sodic soils is the use of a six-inch layer of screened and washed river sand. While evaluation studies of this method are in progress, it appears that the sand acts as a water trap and evaporation barrier: vegetation productivity on sand treatment plots far exceeds productivity on untreated plots. Once fully tested, the method could have significant applicability in revegetation of problem sites.

Seeding Practices

Selection of plant species for permanent revegetation is sometimes made by industry personnel, but more often is based on recommendations or requirements of regulatory agencies when development is on public lands. The current emphasis is on native species of grasses, forbs and shrubs which are adapted to site conditions. Wyoming DEQ Guideline No. 2 (1981) acknowledges that most common proposed land uses after mine reclamation are livestock grazing and wildlife habitat. The guideline underscores the need for programs to produce adequate vegetation cover, suitable vegetation species composition, and adequate vegetation productivity or density. These goals are set to provide soil protection, wildlife/livestock forage, and wildlife shelter. Successful revegetation is determined by comparisons of pre-mining conditions with the revegetation results through sampling procedures designed to assess cover, shrub density, productivity, and tree measurements in each vegetation type or SCS range site including a control area and the area to be disturbed. While no seed mixtures are specified, the guidelines recommend consideration of using seeds from native dominant species which are consistent with the proposed post-mining land use plan, consultation with an SCS range seeding guide

specific for the geographic area for additional species, varying seed mixtures when different soils, exposures and moisture regimes are present on the reclaimed areas, and use of introduced plant species only if further diversity is needed or if they are superior to native species for the specified land use. BLM oil and gas stipulations are less specific than Wyoming DEQ Guideline No. 2 and simply state the responsibility of the operator to establish an acceptable stand of vegetation dependent on BLM approval.

Seeding methods include drilling and/or broadcasting live seed in the fall or early spring (prior to May 15) after the ground has thawed. Frequently, operators report fall seeding to be most successful. They cite two reasons: some species require cold stimulation prior to germinating and early spring moisture from snowmelt and rain is often the major portion of annual precipitation. One specialist states however, that successful seeding for some shrubs (e.g., sagebrush and others with very small seed) can be done when the ground is frozen since the fine seed is trapped in small crevices.

Most seeding is done by drilling through mulches or on a disked or narrowed surface. In some cases, drilling is accompanied by packing in the seed. Broadcast seeding is usually restricted to especially steep slopes, where rocks are prominent, or used to seed species with seeds too large for the drill bore. Where broadcasting is necessary, seeding rates are about twice those used for drilling. One operator reports using two different seeders, a rangeland drill and a seed drill with a broadcast box for shrub seeding.

A variety of species have been seeded and the success of different species has varied between sites. In Wyoming, mine reclamationists commonly use wheatgrasses to establish vegetative cover. Western, thickspike, pubescent, bluebunch, beardless, and slender wheatgrasses and streambank quackgrass have been included in seeding mixtures. Other grasses used by some operators include smooth brome, timothy, orchard grass, indian ricegrass, squirreltail bottlebrush, galleta hiliaria, Great Basin wildrye, Russian wildrye, needle-and-thread, green needlegrass, blue gramma, and barley, which is used primarily as a stubble crop. During the early 1970's, crested wheatgrass was commonly encountered in revegetation work. Currently, none of the operators contacted employ this species because agencies emphasize improving vegetative diversity through the use of native species and because they recognize the limited forage value of crested wheatgrass.

An extensive variety of native forbs have also been tested or included in seeding mixtures. Legumes such as various clovers, sweetclover, milk vetches are used along with introduced alfalfa to establish cover and promote nitrogen fixation. For the most part, forbs become established along with grasses during revegetation efforts. On the other hand, with the exception of a few species, shrub establishment has been difficult and mining companies have invested considerable time and money to produce shrub revegetation. Fourwing and Gardner's saltbrush and shadscale grow well from seed, either drilled or broadcast. However, several contacts recommend caution when using seeds of these and other shrub species. Local ecotypes of shrubs have been emphasized

in reclamation programs in lieu of varieties imported from southwestern and northern states.

Saltbrushes also grow from dormant seeds contained in reapplied topsoil. Likewise, big sagebrush and black sage are found growing from topsoiled seed sources. Considerable variation in successful sagebrush growth has been reported. Apparently, reclamation projects in higher precipitation zones have more sagebrush success than those in drier climates. However, the use of a sand cover (mulch) in Wyoming's Red Desert (see above discussion under Seedbed Preparations) produced good responses of planted seedlings of big sagebrush, fringed sage, four-wing saltbush and Douglas rabbitbrush. Mixed results have also been noted for growth and survival of other shrubs including, greasewood, winterfat, rubber rabbitbrush, antelope bitterbrush, serviceberry, Wood's rose, snowberry, current, sumac, and, in riparian areas, willows, silver sage, and cottonwoods. Often, use of tublings or containerized plants produced more success than seeding shrubs. But these are expensive and often spring frost, early autumn frost, or summer drought have been responsible for limited survival and few returns for the financial investment.

Probably the most successful shrub establishment programs employ local transplants or depend on viable seed in topsoil. There are, of course, different means to this end. Short turnover times between topsoil removal and re-application enhance shrub growth. An apparent augmentation of this procedure is the removal of all shrubs and re-application with topsoil, either as a mixture or using the removed shrubs as a ground cover and potential seed source. This second practice can also inhibit soil erosion since the scattered shrubs intercept precipitation, reduce splash erosion, and retard runoff velocities. Another successful practice reported is stripping both topsoil and native vegetation intact with a large scraper and re-depositing the entire soil-vegetation pad on a reclaimed site. Survival of the transplanted shrubs is reportedly good and they may serve as additional seed sources for adapted ecotypes. Furthermore, these "shrub islands" serve to enhance spatial diversity of vegetation/habitats. Other transplanting efforts for both shrubs and trees (e.g., Rocky Mountain juniper, redberry juniper, aspen, ponderosa pine) are relatively successful. Tree spades, and, in one instance, a front-end loader, have been used to extract roots and soil.

Commitments to shrub growth and establishment imply reclamation for wildlife habitat. In fact, some of the primary deterrents are wildlife and livestock. Big game, lagomorphs, and rodents have been held responsible for grazing shrub seedlings and damaging revegetated sites and livestock can compact reclaimed soils. Operators have recognized the need for fencing these sites so that young plants can survive without grazing and trampling. This, however, adds a further expense to shrub revegetation. A further detractant from shrub establishment is the attitude of some land owners and leasees who favor grasses over shrubs. These preferences are certainly valid but, as stated in the beginning of this section, reclamation must be planned with specific land uses in mind and if one is wildlife habitat, the knowledge and techniques related to establishing vegetation diversity and shrub growth are available.

Plant Growth Amendments

Many operators contacted have tried fertilization with nitrogen or nitrogen-phosphorous-potassium mixtures. Of these contacts, most have either discontinued fertilization or are experimenting with fertilizers on test plots. There have been no overwhelming accolades for fertilizers: frequent reports of no apparent difference between treated and untreated sites were the rule in this survey. One operator noted improved grass growth fertilizer, another speculated on fertilizer effectiveness with increasing soil depth, but a third reported that fertilizers mainly benefit weeds and not the intended vegetation. A more specific approach has been tailoring fertilizer mixtures to site-specific soil conditions. However, no evaluation of this procedure compared to vegetation response with alternative methods was recorded.

Although it has been used as a treatment in experimental studies, irrigation is a seldom used practice. Some operators use drip or sprinkler irrigation to enhance spring growth and growth during the first year only to aid plant cover establishment and drip irrigation has been used to assist growth of shrub tublings. Of course, in the arid west, water is limited and often contains dissolved salts which may inhibit plant growth. In one instance, water was obtained from 2000-foot-deep wells, adding to the expense of the reclamation program. Irrigation on 4:1 slopes or greater has been regarded with caution since erosion potential is high. Furthermore, one reclamation specialist reports poor survival once irrigation is terminated in the second year even though irrigated plants have high survivorship during the one year of treatment. The need for drought tolerant plants in these reclamation projects is very important and the use of irrigation may foster growth of non-tolerant genotypes or species which expire once irrigation is removed. This, of course, wastes effort and money.

WILDLIFE MITIGATION TECHNIQUES AND PRACTICES

Reclaimed lands may be expected to change with time as soil development and plant/animal community succession proceeds (Sindelar 1978). Management practices can be employed to direct and possibly accelerate this process of successional change by correcting shortcomings of initial reclamation efforts, protecting areas from disturbance, or manipulating the soil-plant-animal complex toward a directed end. Since wildlife populations are often limited by habitat availability disturbed land reclamation for wildlife involves re-establishment of requisite physical and biological habitat features (Plummer et al. 1968, Harju 1980). This sub-section present an overview of current reclamation practices specifically aimed at wildlife habitat.

Habitat Diversity

Wyoming DEQ Guideline No. 5 (1980, Revision 2) specifies the goal of mine reclamation for wildlife use as the restoration of wildlife species diversity. Preceding this objective, though, is the planning and accomplishment of habitat diversity. This can be implemented early in the reclamation program by creating topographic variation on reclaimed slopes. Indeed, several mining

companies succeeded in producing slope diversity with dips, lumps, and ridges. Furthermore, several mines have left or are planning to leave highwalls in the reclaimed landscape. The primary difficulty in establishing topographic irregularities appears to be educating heavy equipment operators away from attaining smooth slopes. Additional diversity is being pursued through deposition of rock piles and rock lines on reclaimed surfaces. Some operators go further and put extra effort into shrub establishment, whether by seeding, tublings, or transplants, near the rock "out-crops".

On flat slopes or where slopes have not been recontoured for diversity, other methods have been used to promote vegetation patchiness and spatial diversity. Although not yet implemented, one operator plans to revegetate in a mosaic of shrubs and grasses and another has strip seeded shrubs without any grasses in the mixture. Other companies rely on the seeding mixture(s) where different mixtures are designed for lowland, riparian, and upland sites. Creating "shrub islands" by direct removal and re-deposition of soil and live vegetation with large scrapers appears to be a successful and immediate remedy to the vegetation diversity problem. Another company has left islands of trees and shrubs around the mine pit. In fact, these have been used as nesting sites by golden eagles and red-tailed hawks.

Several of the companies contacted have made advances enhancing nesting habitat for raptors. Where highwalls exist after or during mining, they have been used for nesting by raptors such as golden eagles and red-tailed hawks. Company biologists, often with consultation from US Fish and Wildlife Service personnel, have created raptor nesting habitat and moved nests to sites away from disturbances. Nesting boxes for kestrels have been stationed in areas containing no prior nesting sites. All of these programs have been successful. Other biologists report constructing nesting platforms for use by golden eagles and ferruginous hawks. For the latter species, nests have been moved and reconstructed on rock piles and in elevated metal baskets with some success. Tree nests of Swainson's hawk have also been moved by one operator. And one mine reclamation plan specifies excavation of cliff-face holes to encourage relocation of future mine-impacted prairie falcons.

Other efforts include creating nesting islands and platforms for Canada geese, erecting snags near a reservoir for use by ospreys, and constructing nesting boxes for songbirds. Sage grouse leks have been re-located by using sound attractants and decoy for three years before the traditional lek was destroyed, thereby fostering a behavioral pattern prior to the actual need for alternatives. Water impoundments have also been created during the course of reclamation and these provide new habitat to various species. Some effort has been made to plant cattails and willows and stabilize dams with riprap. Some of these ponds are used by nesting waterfowl and other riparian and shorebirds. Other operators state that emergent vegetation comes in naturally on even temporary sedimentation ponds. Trout streams impacted by development have been reclaimed by using silt retention structures, bank plantings of willows and cottonwoods, and riprap on unstable banks. Generally, most companies are committed to "zero surface discharges" and report taking appropriate measures (see Seedbed Preparations and Landform Reclamation above).

Habitat Improvements

Some of the reported habitat diversity projects, above, constitute improvements over pre-mining conditions. Included are creation of raptor nest sites whether through nesting platform construction or leaving highwalls after mine abandonment and construction of water impoundments. In prairie and desert ecosystems, there are few structures available for bird nest sites and where vertical structures are constructed they are used for both nest sites and perches. Transmission lines are also used, especially as perches for large raptors, and the potential for raptor electrocution is present. But most companies report using various anti-perch or alternate perch structures to either reduce the possibility of electrocution or to offer more attractive perching sites.

Very few operators stated that off-site habitat improvement projects were undertaken to compensate for wildlife habitat loss during development. Exceptions include off-site development of Canada goose nesting islands in an adjacent reservoir and a trout stream restoration project that was, in fact, unrelated to and unaffected by mine site development.

Most mitigation for wildlife and wildlife habitat has been avoidance of key ranges or nest sites. Buffer zones around raptor nests are commonly defined and avoided. Preventative measures to reduce impacts also are employed such as the use of anti-perch structures on transmission lines and earthen bridges facilitating movement over surface pipelines. Searches for threatened and endangered species commonly occur during baseline inventories, but by themselves, do not provide solutions to mitigation but may identify potential problems. The focus of reclamation projects has been on-site habitat restoration, or in some cases improvements. The concept of mitigation through off-site improvements to compensate for on-site disturbances appears to have little acceptance with companies.

MONITORING PROGRAMS

Erosion

Most erosion monitoring is conducted in the form of periodic visual inspections of reclaimed sites. If gulleying, washouts, or runoff are excessive repairs are implemented. A few companies monitor precipitation infiltration in soils and/or suspended solids in streams draining mine operations. Several report checking water quality upstream and downstream to assess the sedimentation contribution from the mine or reclamation project.

There has been some research by companies to assess erosion potential on plots with simulated rainfall. Also, hydrologic studies have assisted reclamation of drainages but drainages on reclaimed land have also been allowed to form naturally with occasional repair of channel cuts.

Vegetation

Reclamation personnel do inspect vegetation success although few have reported quantitative evaluations. Where re-vegetation has been subjected to various treatments such as seed mixtures, mulches, fertilization, and/or irrigation, quantitative evaluations of vegetation responses have been conducted. Monitoring revegetated areas for species diversity, cover, and productivity (biomass) has been done but frequencies of these evaluations range from every year to every two years. Some companies plan to intensify monitoring as bond-release time nears. One company has used photoplots to document vegetation growth over time. One innovative reclamation specialist states that antelope, deer, and some limited elk diet analysis has been done off-site to judge the adequacy of seeding mixtures for reclaiming wildlife habitat.

Wildlife

Various wildlife monitoring programs, including the big game diet analysis study noted above, are in effect. One company has conducted a raptor banding and telemetry project for on- and off-site nests. The information gained from this project can be used to examine survivorship and nest use consistency of raptors impacted by mine developments. The US Fish and Wildlife Service has conducted movement and habitat use studies of big game and game birds prior to and during mining.

Other company-maintained monitoring programs include programs to monitor big game and lagomorph use of reclaimed and native vegetation, small mammal and passerine bird use of reclaimed sites, checks on raptor nest sites, sage grouse lek attendance big game young production and winter range use for up to two miles beyond the mine permit boundary. Other companies rely on state or federal agencies to conduct wildlife monitoring studies. Some companies can only provide anecdotal accounts of wildlife use of reclaimed areas even though quantitative baseline data may have been obtained. Thus, no comparisons with pre-development or unaffected areas are possible. Only one operator has reported monitoring road impacts by conducting road-kill counts along site access roads.

CONCLUSIONS

There is considerable variation in all phases of the reclamation process among the companies contacted in its survey. While some companies, usually those involved with reclamation for 10 years or more, have undertaken innovative approaches to various problems, others rely on agency specifications. Many companies have realized that, in the long run, experimental trials with various techniques ranging from topsoil turnover time to seeding mixtures and surface treatments provide valuable information that can save time and money during a reclamation program. Realization of a program's success or failure can only be accomplished through adequate monitoring, but quantitative evaluations of erosion control, revegetation, and wildlife use of reclaimed areas are by no means universal.

This survey of reclamation practices was not intended as an evaluation of various company practices. Operators are located in such a diverse area that local variations in topography, precipitation, soils, flora and fauna preclude citing one technique as superior over another. Rather, the survey has provided a summary of current or planned practices. The summaries presented in Tables E-1 through E-6 cover practices used in topsoiling, erosion control surface preparation, methods used in re-vegetation programs, reclamation and mitigation of wildlife habitat, and monitoring reclamation programs. The tables provide an indication of relative use frequencies of the various approaches that were reported during telephone interviews.

Two shortcomings of reclamation programs were apparent as a result of this survey. The two are related to communication and evaluation of program success or failures. Many companies report program success but often after a period of trial and error. Experience has lead some to try novel solutions to reclamation problems. These solutions are, of course, enthusiastically endorsed for the local reclamation program but may have wider applications. The problem remains communicating these successes, and failure as well, to other operators. This would enrich current knowledge and provide multiple options when similar problems are faced. While mine companies in Wyoming provide reclamation plans and annual reports to Wyoming DEQ in Cheyenne and WMA has abstracts of research projects on file, these are often inaccessible to other industries and companies operating in other states.

Furthermore, objective evaluations of program results are often lacking. And, where quantitative studies have been conducted, there may be no way to conduct between-company comparisons if different techniques and parameters are used. Standardization, while possibly not feasible, could lead to identification of potentially successful techniques that could be employed once site specific parameters were known. Thus, information about useful techniques can stimulate program options but without specific conditions and response of a particular treatment, application to a new situation may still involve experimentation, loss of time, and increased expenditures.

TABLE E-4

SUMMARY OF METHODS USED TO ESTABLISH VEGETATION ON RECLAIMED SITES

A. Seed Application/Shrub Establishment

Seed Mixture	in Problem Areas	Drilling Broadcasting Shrubs	Broadcasting Containerized Shrub Planting	Shrub Tubules	Shrub/Tree Transplants
73%	20%	27%	7%	13%	40%

B. Vegetation Used in Reclamation Programs

Wheat- Grasses	Native Native Grasses	Additional duced Grasses	Intro- Native Forbs	Intro- duced Legumes	Intro- Salt- bushes	Sage- brush	Sage/ Winten- fat	Grease- wood
80%	33%	47%	20%	33%	60%	53%	27%	13%

Continued

Rabbit- brush	Bitter- brush	Mesophytic Shrubs	Riparian Shrubs/Trees	Juniper	Ponderosa Pine	Introduced Trees
27%	20%	20%	7%	27%	13%	7%

C. Plant Growth Amendments

Fertilizers			Irrigation			
None Used	Soil Analysis Some Fertilization	Followed by Fertilization	First None Used	Seedling Entire Site	Seedling Growth Season	Shrubs Only
20%	70%	7%	60%	0%	27%	7%

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TABLE E-5

SUMMARY OF METHODS USED TO RECLAIM WILDLIFE HABITAT, MITIGATE HABITAT
LOSSES, AND ENHANCE HABITAT DIVERSITY

A. Mitigation of Lost Nesting Habitat/Improvement of Nesting Habitat					
Leave Highwalls	Raptor Nesting Platforms/ Structures	Kestrel/ Songbird Nest Boxes	Snags	Canada Goose Nest Platforms	Planting Vegetation on Pond Banks
20%	27%	20%	7%	7%	13%
B. Mitigation of Disturbance/Hazards					
Buffer Zones around Raptor Nests	Raptor Nest Relocation	Sage Grouse Lek Relocation	Anti-Perch/ Electrocution Devices	Bridges on Surface Pipelines	
13%	20%	7%	27%	7%	
C. Reclamation for Wildlife Habitat Diversity					
Topographic Slope Irregularities	Rock Out-Crops	Vegetation Mosaics/ Strips	Different Seeding Mixtures	Shrub Patches	Islands of Native Vegetation
33%	53%	13%	13%	20%	7%
Continued					
Water Impoundments Temporary	Water Impoundments Permanent	Planting Streamside Vegetation	Channel Stability Improvements		
20%	40%	7%		13%	

TABLE E-6

SUMMARY OF RECLAMATION MONITORING PROGRAMS

A. Erosion				
Visual Inspection	Water Quality In Drainages	Infiltration	Experimental/ Simulations	None
40%	27%	7%	13%	27%

B. Vegetation			
Visual Inspection	Periodic Quantitative Evaluation	Experimental Treatments	None
27%	47%	20%	13%

C. Wildlife			
Anecdotal Only	Use of Native vs. Reclaimed Sites	Seasonal/Annual Big Game Census	Seasonal Raptor/ Game Bird Census
33%	33%	40%	20%

Continued

On-/Off-Site	Movement Studies	Survivorship
	Studies On-/Off-Site	Road Kills
20%	7%	7%

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RECLAMATION PRACTICES

Contact Date _____

Person Contacted _____ Phone _____

Company _____

Resource _____ Reclamation Type _____

A. Revegetation/Reclamation Methods:

1. Duration _____

2. Topsoil/Subsoil Stockpiling (Separation) _____

3. Recontouring _____

4. Soil/Slope Stabilization _____

5. Mulching _____

6. Other Seedbed Preparations _____

7. Seed Mixtures _____

8. Shrub Establishment _____

9. Fertilizers _____

10. Irrigation _____

B. Wildlife Habitat:

1. Habitat Diversity _____

2. Nesting Structures _____

3. Water Sources _____

4. Habitat Improvements:

a. On-Site: _____

b. Off-Site: _____

5. Other _____

C. Monitoring:

1. Erosion _____

Technique _____

2. Vegetation _____

Technique _____

3. Wildlife Use _____

Technique _____

4. Program Success _____

5. Reports Available _____

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